

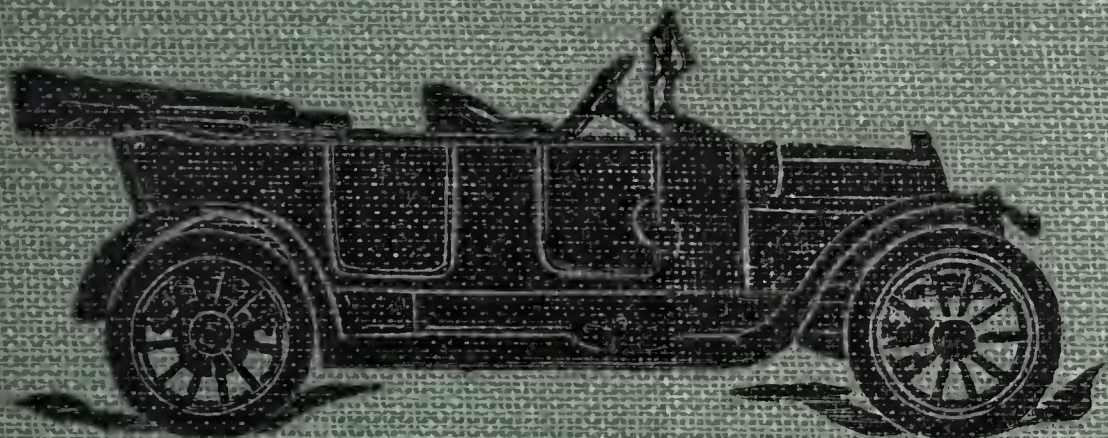
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ENGELMAN'S AUTOCRAFT





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AUTOCRAFT

AUTOCRAFT

Being an Instructive Study of the Automobile; Its Care
and Management; How to Drive; Locating Troubles
and Repairing Them; With Chapters Exploit-
ing Some of the Latest Devices Used
in Automobile Construction.

BY

ROY A. ENGELMAN

100 ILLUSTRATIONS

1923
AMERICAN AUTOMOBILE DIGEST
Cincinnati

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The Automobile Engine—Its Operation and Construction

AUTOMOBILE engines are defined according to their cycle of operations. This term “cycle” is the successive actions of the piston, commencing when a certain relationship exists and starting again with the next recurrence of the same relationship. There are four events which must occur in an engine cylinder before it can repeat:

First—Drawing in a fresh charge.

Second—Compressing this so it can be ignited.

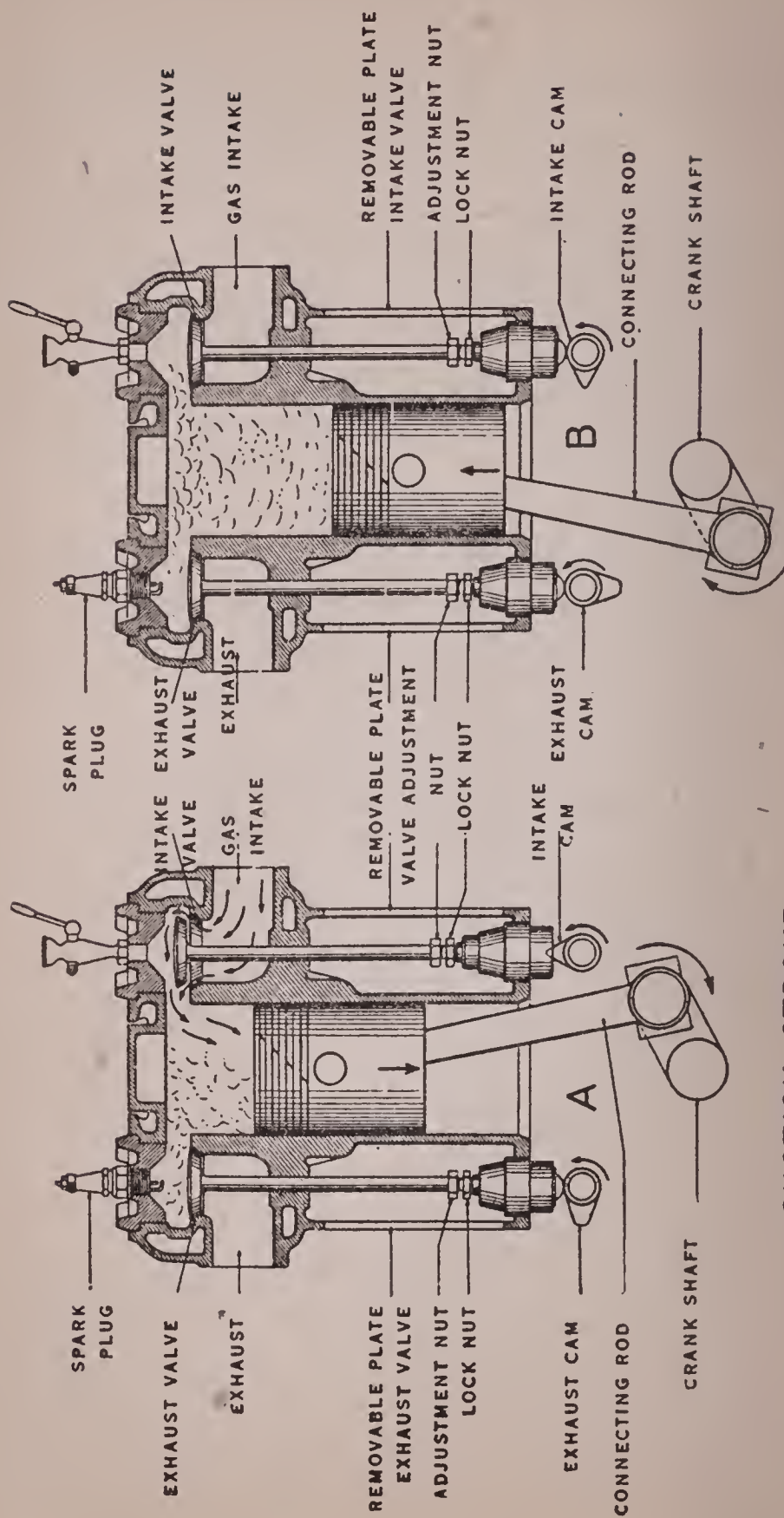
Third—The explosion or expansion of the gas.

Fourth—The discharge or exhausting of the spent gases.

These events are termed the cycle of operations, and these may be accomplished in two ways: first, by combining two of the events in one stroke of the piston; or second, by performing each operation during one stroke of the piston. The former is termed the two-cycle or two-stroke type and provides a power stroke every revolution, while the latter provides a power stroke every other revolution and is termed the four-stroke or four-cycle type.

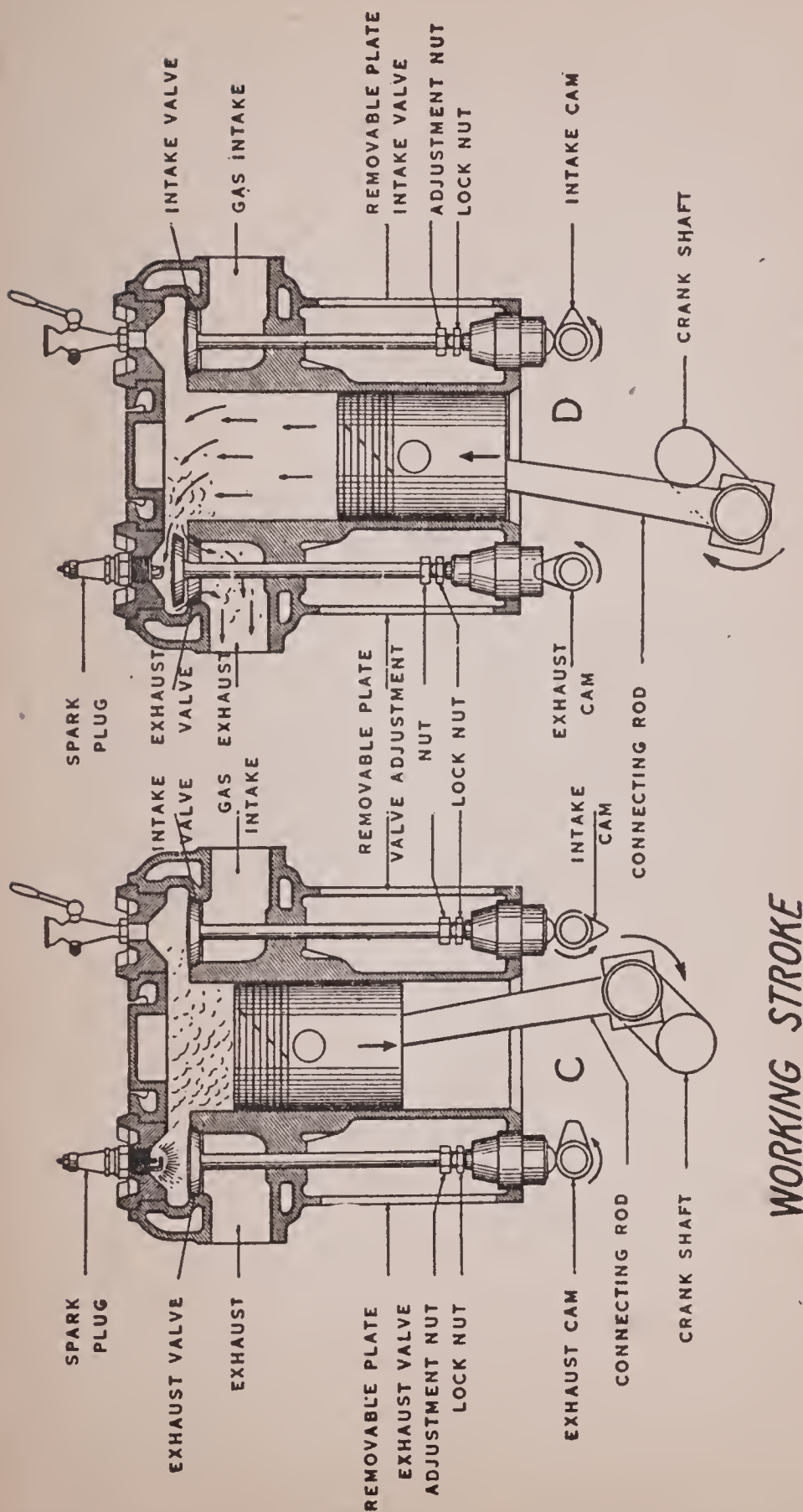
THE FOUR-CYCLE MOTOR.

The four-cycle motor is now almost universally used for motor vehicles, and although the same operations must occur, they are controlled entirely by mechanical means. The cylinder ports are replaced by valves which are either of the poppet, piston or sleeve type. The four-cycle type has been previously designated as a



SUCTION STROKE

COMPRESSION STROKE



EXHAUST STROKE

Fig. 1.—Diagram of the Strokes of a Four Cycle Motor. Water Jacket, Valves, Springs and other Details Are Not Shown.

four-stroke engine, that is, one stroke of the piston is required to perform each operation. These four piston strokes are shown in Fig. 1. The intake, or suction stroke, is shown at "A" and it will be noted that as the piston travels downward the inlet valves open and permit the piston to draw in a fresh charge of gas from the carburetor. This valve remains open until the piston has passed the bottom of its stroke, and shortly after the piston starts on its upward completion of this piston stroke. During this upward stroke, which is shown at "B," Fig. 1, the gases are compressed within the combustion chamber and prepared for ignition. The piston has now made two strokes and the crankshaft one complete revolution, while but two operations have taken place.

After completing the compression of the gases they are ignited by inducing an electrical spark to occur within the combustion chamber, which ignites the gases and raises their pressure four or five times what it was previously, causing them to expand and force the piston downward again, thus converting the heat of these gases into useful energy or power. This stroke, known as the power stroke, or working stroke, is shown at "C." Now as the piston nears the bottom of this stroke the exhaust valve begins to open, as shown at "D," and the spent gases begin to escape. This exhaustion of spent gases continues all through the following return stroke of the piston, the valve remaining open until the piston has again started downward a short distance. This completes the four strokes and permits the motor to again resume its cycle of operations.

In this illustration the valves are shown on opposite sides and although various valve positions may be found in practice, this position simplifies the illustration considerable.

CRANKCASE, CYLINDERS AND THEIR PARTS.

In elementary form, the construction of a motor car engine is quite simple, being comprised of a cylinder, a piston provided with rings operating within the cylinder, valves which permit proper timing for the entrance and discharge of the gases, a connecting rod for connecting the piston with a crankshaft, a case or housing which supports this shaft and also a cam shaft which opens and closes the valves through cams mounted on the latter and a set of push rods.

From what has been mentioned above in explaining the cycle of operations, it can readily

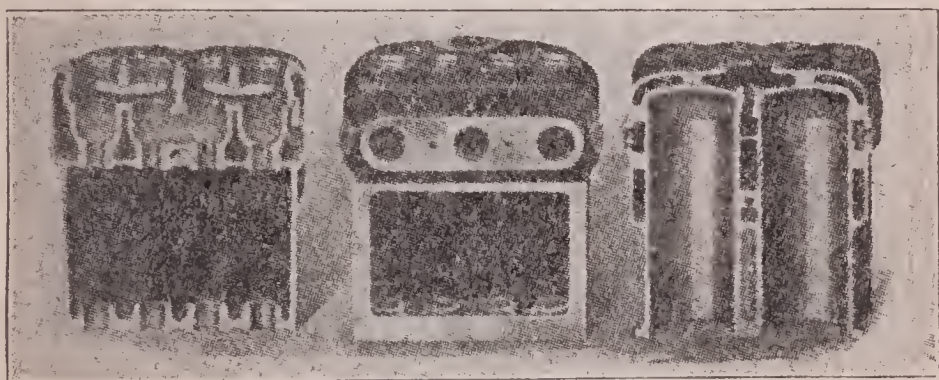


Fig. 2.—Sectional View of an "L" Head Cylinder.

be understood that the piston travels up and down, forming a reciprocating motion, while the crankshaft rotates in its bearings in order to impart a turning effort to the driving wheels. This conversion of reciprocating motion into rotary motion will be described later.

THE CYLINDER.

The cylinders are usually gray iron castings, provided with water jackets or cooling fins, and have an open and a closed end, as shown in Fig. 2. The inner walls are made very smooth by grinding, lapping or reaming so that the piston

with its rings can slide freely within the cylinder. The closed end forms the combustion chamber and houses the valves, which are inserted through small openings in the head. The crankcase is the main housing for all parts and has the cylinders bolted to it. Cylinder construction varies according to the location of the valves and they may be cast single, in pairs or in blocs of three, four or six.

THE PISTON AND RINGS.

The piston of a gasoline engine is of the trunk type, being a trifle longer than the diameter of the cylinder. At a point approximately its center, bosses are formed on the inner walls on opposite sides which receive the piston pin, which acts as a hinge for the upper end of the connecting rod. Above and below this piston pin, grooves are formed which receive the piston rings. These pistons are made a trifle smaller in diameter than the cylinder, to permit metal expansion, while the rings permit of flexibility so that the gases cannot escape by the rings.

THE CRANKSHAFT.

This is a horizontal steel shaft carried in bearings, inside of the crankcase, and it is provided with a number of offsets corresponding to the number of cylinders. These offsets are termed the crankpins and carry the large ends of the connecting rods. The shaft also carries the fly-wheel.

THE CONNECTING ROD.

The connecting rod forms an intermediate link between the piston and the crankshaft and its function is to transmit reciprocating motion into rotary motion. This conversion of motion may

be described as follows: When the piston is at its top center in the cylinder the crankpin is standing vertical, however, as the expanding gases force the piston downward, the crankshaft is constrained and revolves downwardly. The crankpin which carries one end of the connecting rod passes through its horizontal position and finally reaches a position vertically below the center of the shaft. This same action of the crankshaft takes place as the piston moves upward, until the crankpin has made one complete revolution. Thus the upper end of the connecting rod reciprocates in harmony with the piston, while its lower end rotates in harmony with the crankpin. Fig. 3 illustrates a four-cylinder engine crankshaft with the connecting rods and pistons assembled to it.

THE FLYWHEEL.

The flywheel is used for storing energy developed during the power stroke, which liberates itself during the idle stroke. This function will be explained later under the caption of multi-cylinder engines.

THE VALVES.

The valves permit the entrance and escape of the gases at the proper time. These valves are usually of the poppet type and consist of a disc of metal with a stem on one end, which encloses a circular opening in the combustion chamber, being held against its seat by a coiled spring.

THE CAMSHAFT.

The opening and closing of these valves is controlled by the camshaft, which carries a cam for each valve. The camshaft is driven by gears from the crankshaft and in proper

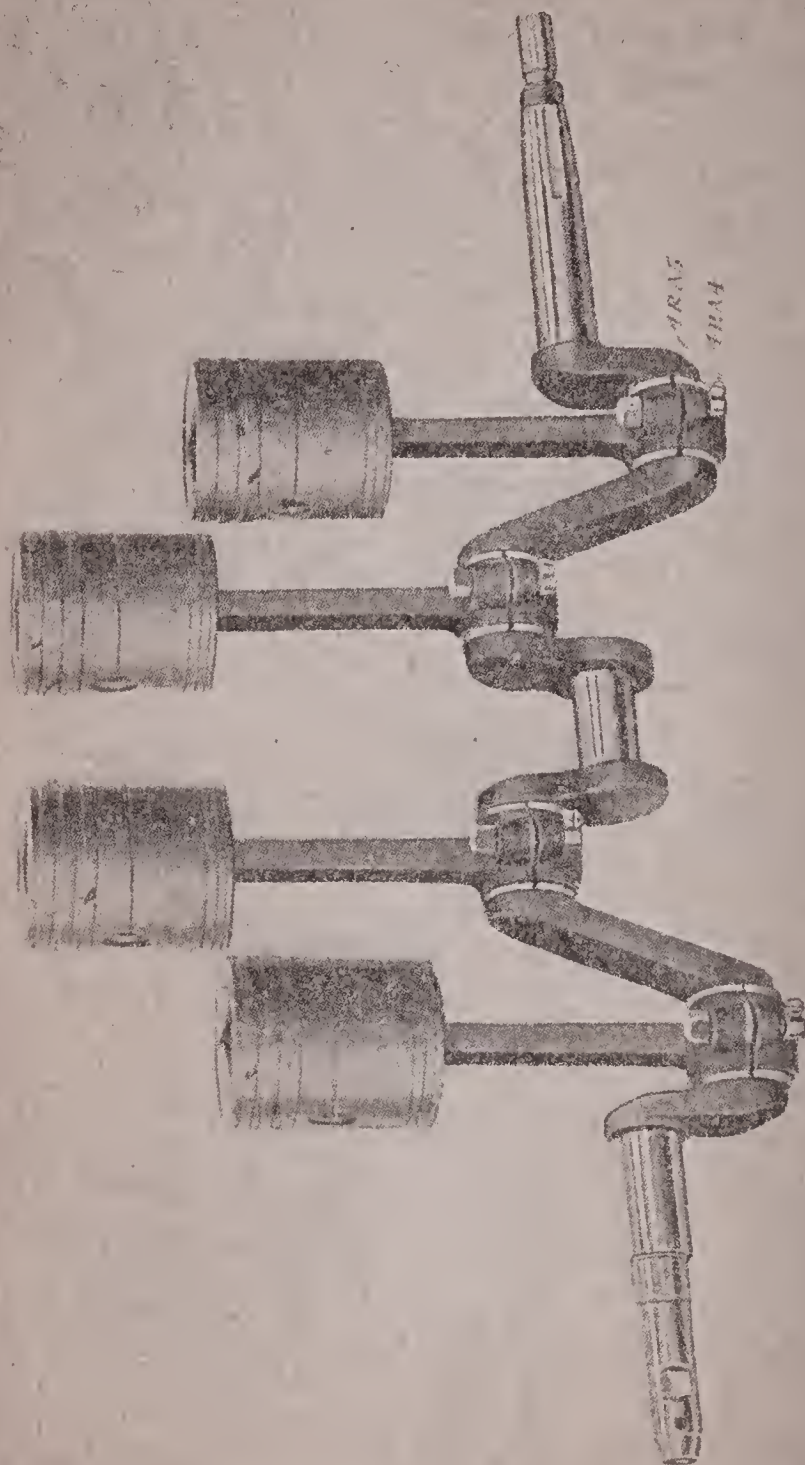


Fig. 3.—Cylinder Crankshaft, Connecting Rods, Pistons and Rings.

time relation with it. The cam causes the valve to raise from its seat while the spring performs the function of closing it.

In this case it is necessary to convert a rotating motion into a reciprocating motion, as the camshaft revolves while the valves have a reciprocating motion. However, as no permanent connection is necessary, this becomes quite sim-

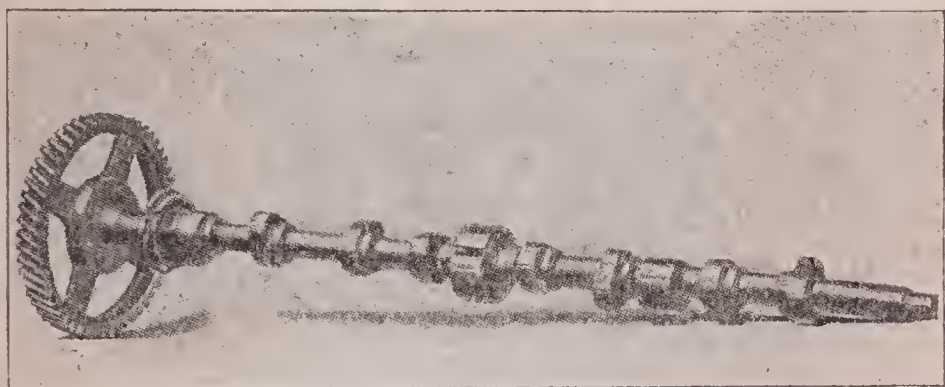


Fig. 4.—Assembled Camshaft, Showing Cams, Bearings and Helical Tooth-Driving Gear.

ple, by providing a push rod, one end of which communicates with the valve stem while the other rests on the cam. This push rod is provided with a suitable bearing so that its relation with the camshaft can always be maintained. These push rods are always provided with an adjustment so that as little lost motion as is practical may exist between the valve stem and the cam. Fig. 4 illustrates a typical four-cylinder camshaft.

THE CRANKCASE.

This forms the main structural part of the motor, carrying the cylinders, crankshaft, camshaft and accessories, and in turn is supported in the vehicle frame. It protects these important parts from mud and dust and also performs important functions in connection with the lubrication of the motor. The general construction de-

depends entirely upon the design of the engine, as regards cylinders, valve location, bearing mounting, etc. There are two general types, the divided type and the barrel type, the latter being shown in Fig. 5, together with the oil reservoir.

CLASSIFICATION OF MOTORS.

Motor car engines are classified according to the type of valve employed and its location in the cylinder, as this point generally controls entire construction, as well as the various factors which enter into its design.

These various types classified by the valve locations and type are as follows:

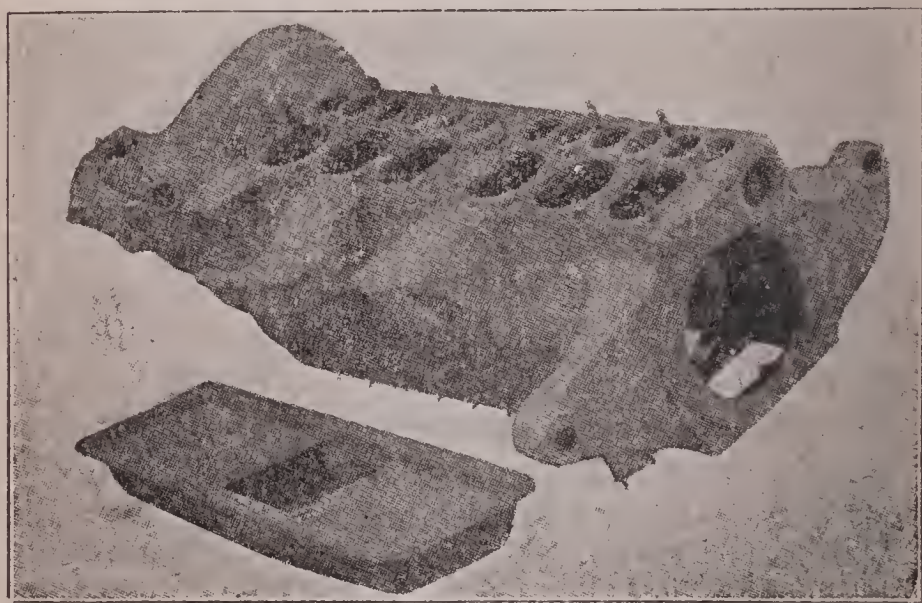


Fig. 5.—Six Cylinder Barrel Type Crankcase and Oil Reservoir.

POPPET VALVE TYPE.

“T” head—A type in which all valves are located in pockets on opposite sides of the cylinders.

“L” head—A type in which all valves are located side by side in one pocket, or either the right or left hand side of the cylinder.

“Valve in head”—A type in which all valves

are located in the cylinder head, placed vertically or at an angle.

There are also several other types which are combinations of those depicted above, having one valve in the head and the other in a pocket at the side, or both valves in a pocket at the side, one valve being located above the other.

At present the "Valve in head" and "L" head motors are by far the most popular, although the other types are also used. In order to cover the general practice of engine construction, the writer is presenting a series of illustrations which cover all types of engines, together with descriptions, which will serve to point out the features of each construction.

MOTOR CONSTRUCTION.

Fig. 6 depicts the "L" head engine which is used on a number of popular-priced cars, and serves as an excellent illustration of the conventional type of "L" motor. The cylinders are cast in one bloc, integral with the upper half of the crankcase. The valves are located on the right hand side and the cylinder head is made detachable. The connecting rods are drop forging of I-beam section and are provided to facilitate bearing adjustment. The crankshaft is also a drop forging, however, it is mounted upon two bearings, one at the front and one at the rear, while lubrication is by the recirculating splash type, and cooling is by the thermo-syphon system.

Fig. 7 illustrates the six-cylinder "L" head engine with en bloc cylinders and crankcase. The cylinders are also provided with a detachable head, but the crankcase is of a modified barrel type with a pressed steel oil pan on lower half. The crankshaft is of the three-bearing type, while the camshaft is driven by a

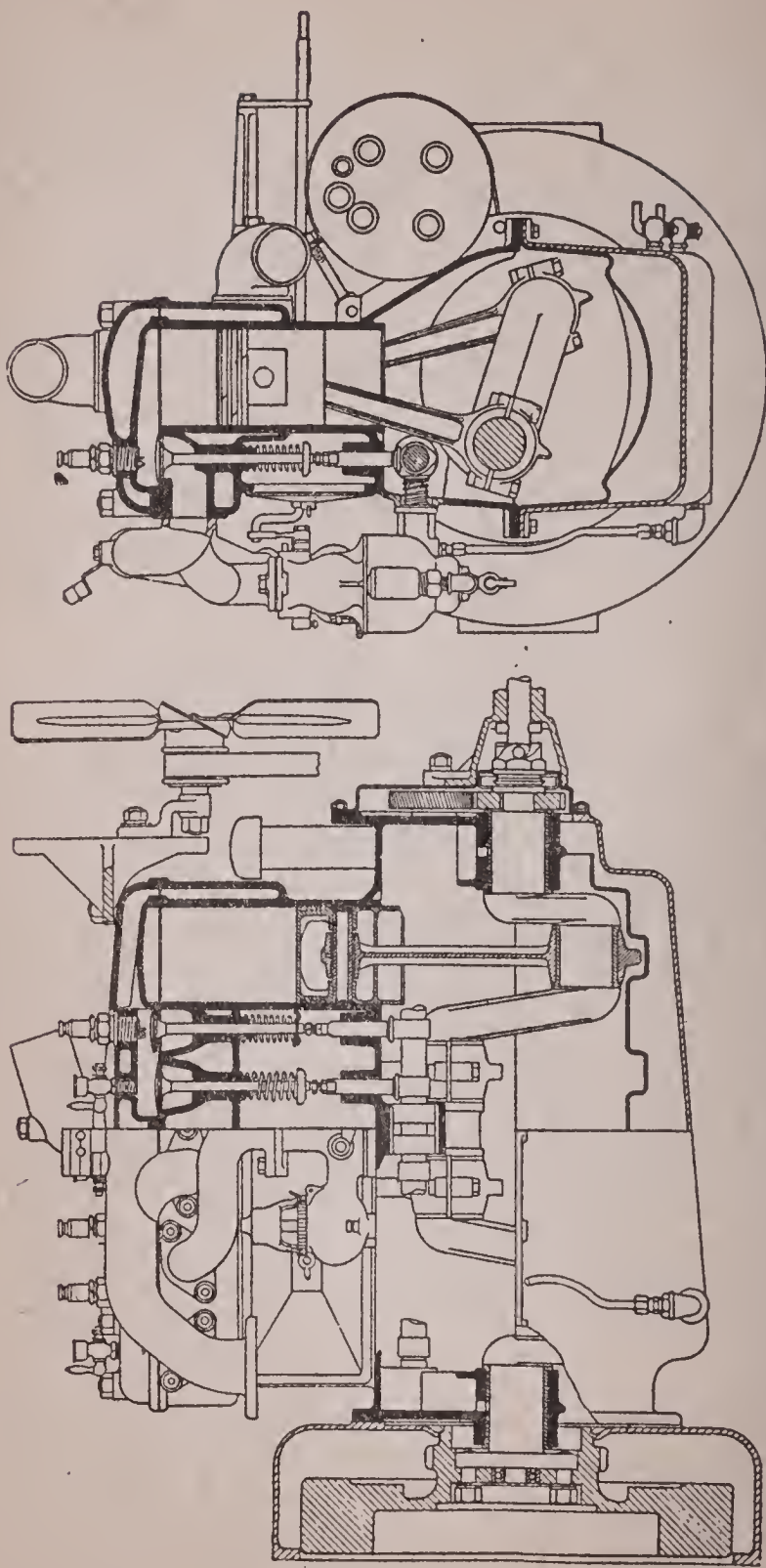


Fig. 6.—Four Cylinder Bloc Motor "L" Head Type with all Valves on the right hand side.

silent chain instead of helical gears. Both these illustrations show how the valve stems may be enclosed and the direct valve operation through push rods of the mushroom type in Fig. 6 and the roller type in Fig. 7.

Fig. 8 illustrates the "T" head motor, in which the valves are located in pockets on the opposite sides and are operated through push rods and a camshaft on each side of the engine. It is of conventional design.

There are two types of valves in the head engines which differ chiefly in the location of the camshaft. This may either be mounted in the crankcase or on top of the cylinders.

Fig. 9 illustrates the six-cylinder valve in the head engine in which the valves are located in the cylinder heads and are operated through push rods and rocker arms from a single camshaft located in the crankcase. Both the crank and camshaft are provided with bearings so located that each pair of crank pins are supported between bearings.

When the camshaft is located on the cylinders, the valves are operated direct from the cams, and the valve stems are threaded to receive an adjusting nut. In this position the camshaft can either be driven through gears or a silent chain.

Another type of motor still exists in which one valve is operated direct and the other through a push rod and rocker arm. This is known as a combination of the valve in head and "L" types. The Reo four-cylinder engine, Fig. 10, offers an excellent example of this type and one in which the cylinders are cast in pairs and bolted to a barrel-type crankcase. But one shaft is used, which is provided with three bearings, while the crankshaft also has three bearings.

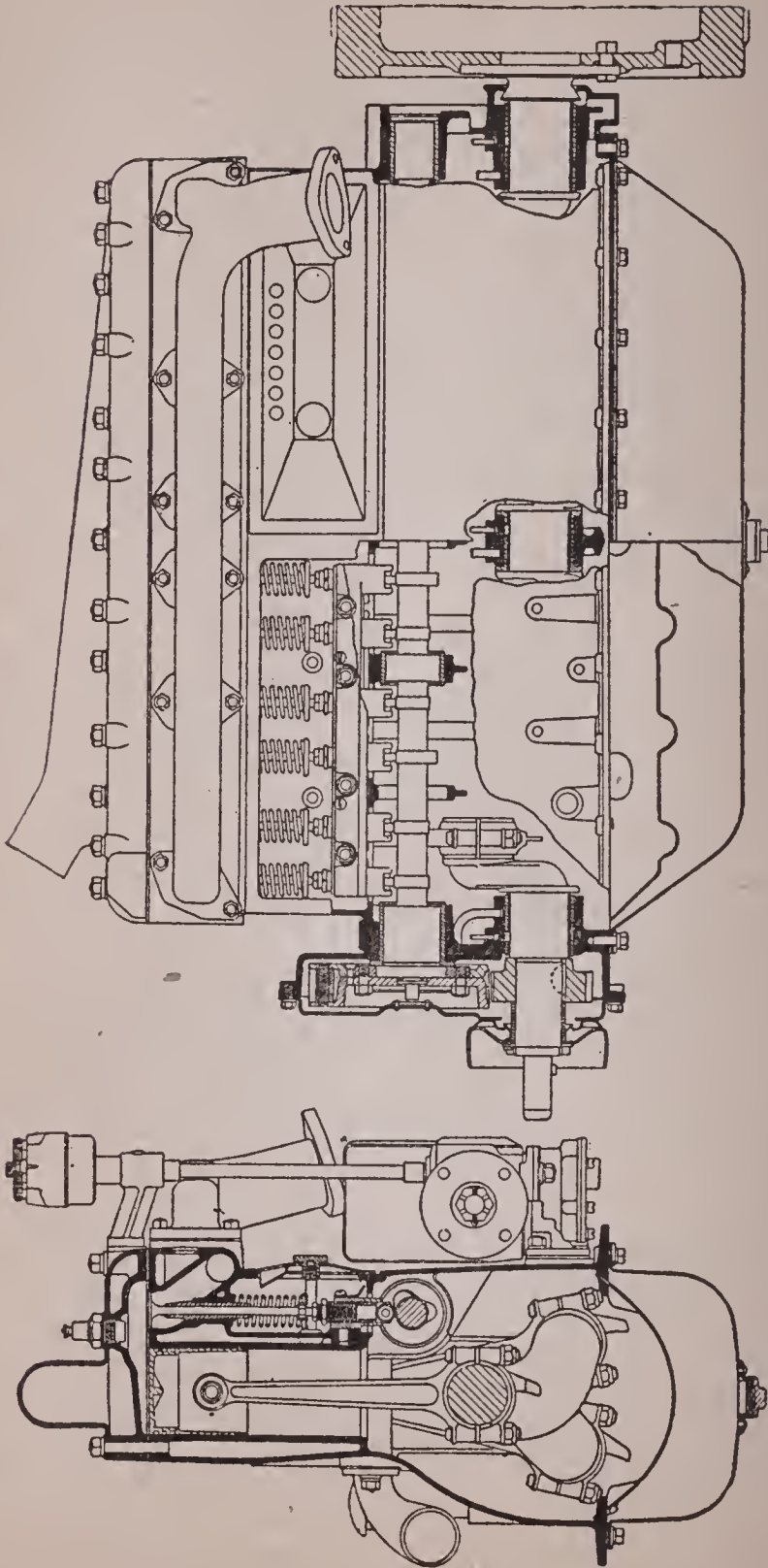


Fig. 7.—Cross Section and Part Longitudinal View of the Six Cylinder "L" Head Bloc Motor.

There are various methods of driving the magneto and the water pump, and are dependent upon the general scheme of design.

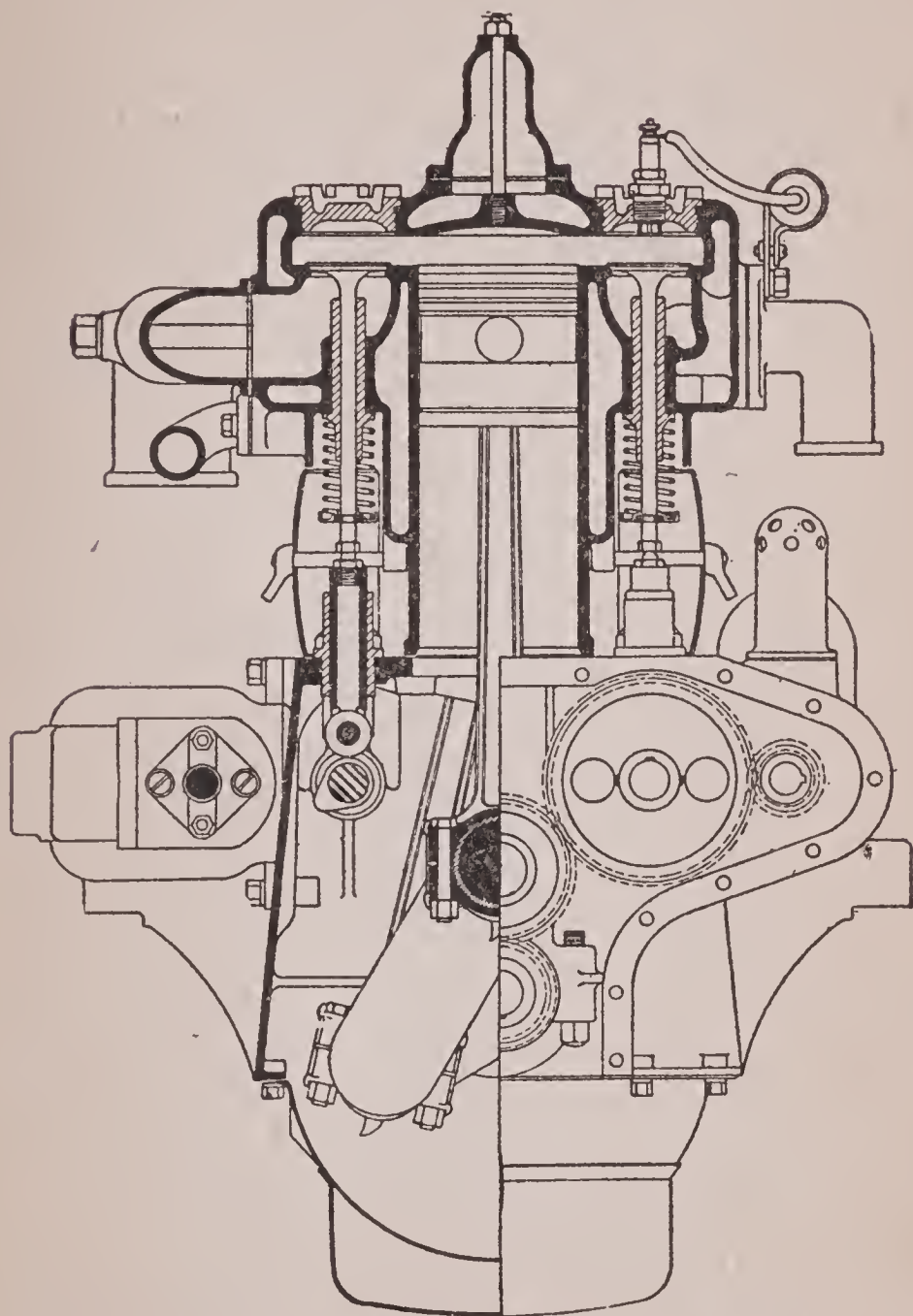


Fig. 8.—Cross Section View of the Mercer T Head Engine with valves on opposite sides.

V-TYPE ENGINES.

The trend of engine design has been toward increasing the number of cylinders and the writer

knows of but few exceptions when makers have decreased the number of cylinders.

The present eight and twelve cylinder engines which are gaining favor rapidly, are built in what is termed V form. All cylinders could be arranged in a row, but this would present some disadvantages, while the V type engine presents a very moderate length and in each case requires a somewhat shorter hood than a vertical engine of equal power, giving a somewhat roomier body with the same wheel base.

Makers of these engines claim they exceed the six cylinder engine in flexibility, uniformity of torque and freedom from vibration. They are very smooth in operation as there is very little lapse, during impulses, eliminating the laboring jerks and jars.

The development of the V type engine has been so rapid that design practice is rather chaotic and there is no uniformity in general layouts.

These motors are generally of the L head or valve in the head type, as these two valve locations seem to form the simplest arrangement. Opinions also differ as to the best method of attaching the connecting rods and one finds two methods in vogue. These are placed either side by side, or one is forked and the other operates on a bushing within the fork of the former. There are also two camshaft constructions, one having eight cams and the other sixteen, while the valves may either be operated direct or through rocker arms. With the side by side connecting rod arrangement it is necessary to stagger the cylinder blocks to center them with the connecting rods.

V-ENGINE CONSTRUCTION.

The eight-cylinder V engine, Fig. 12, in some respect follows accepted practice, with cylin-

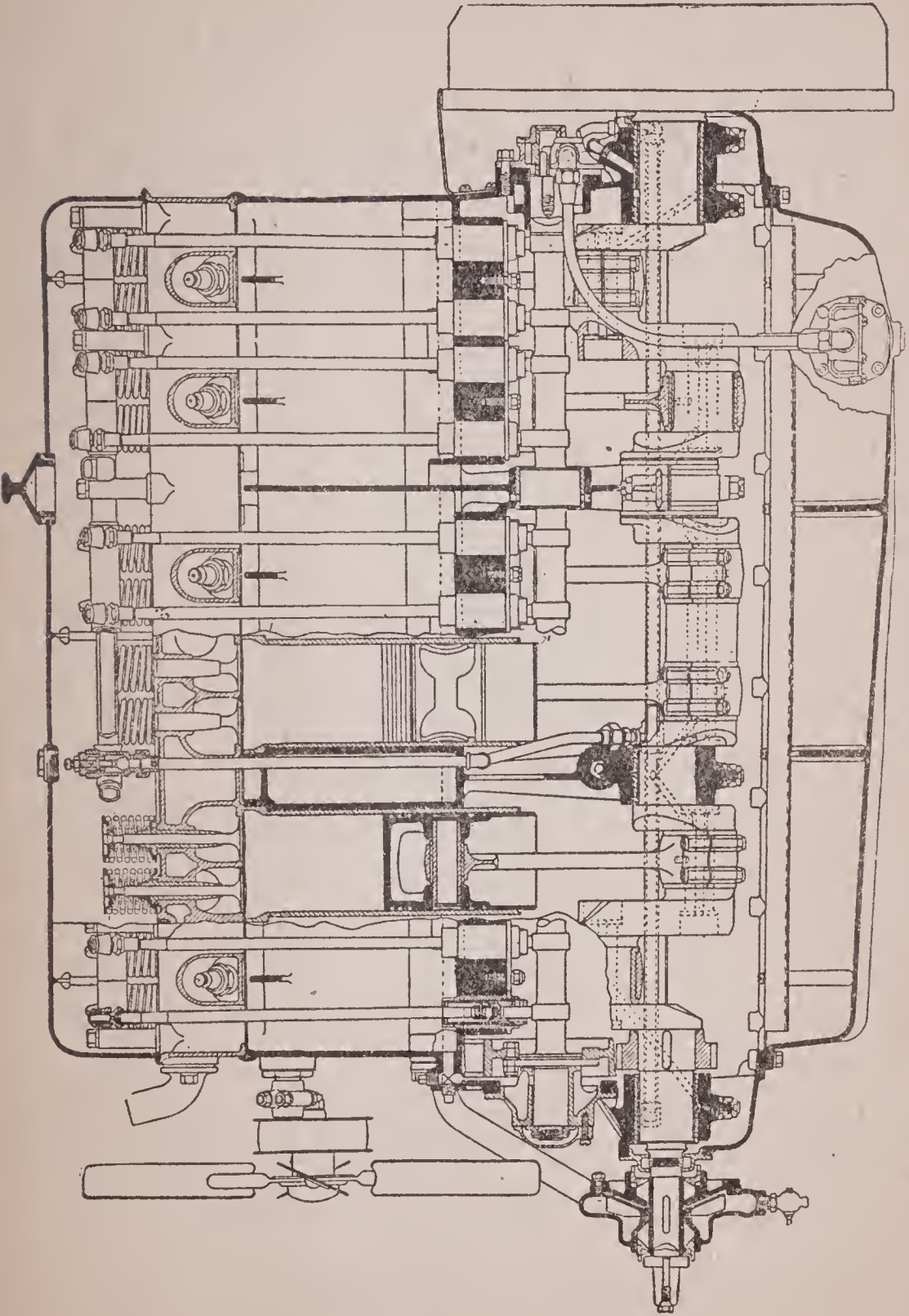


Fig. 9.—Longitudinal Section View of the Valve in Head Six Cylinder Engine.

ders arranged in blocs of four, side by side, connecting rods and rocker operated valves from a single shaft having sixteen cams. The engine is cooled by a forced water circulating system, which is maintained by a double water pump driven by a cross shaft at the front end of the engine, which also provides for driving a magneto when necessary. This water pump has

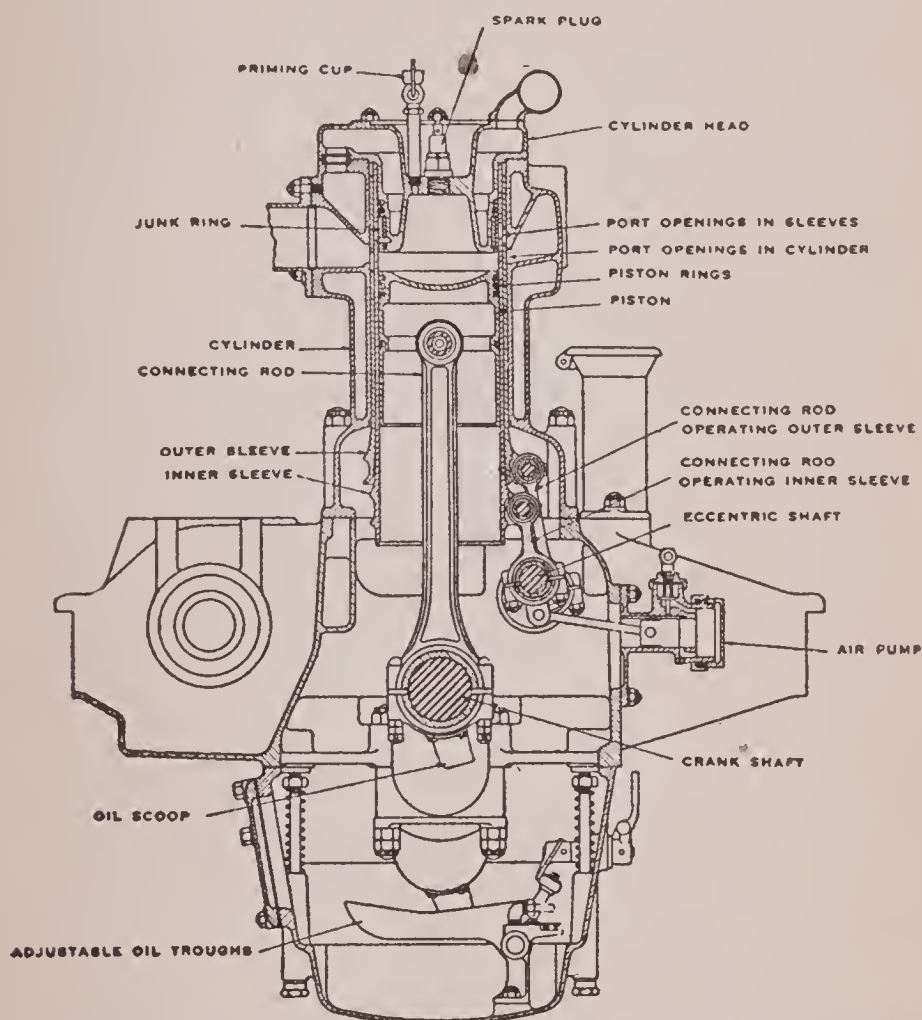


Fig. 11.—Cross Section View of a Stearns-Knight Engine.

two discharge pipes, one leading to each bloc of cylinders. The return path is by outlets for each cylinder bloc, the outlets being located opposite each exhaust valve.

Lubrication of this engine is by a pressure feed system to all journals, regulated by a safety valve,

which discharges the excess pressure of oil to the timing gears at the front end.

Fig. 14 is somewhat different from the type mentioned above. The cylinders and crank case are cast integral and the valves are located in the cylinder heads, and are operated direct from the camshaft which has a cam for each valve. The

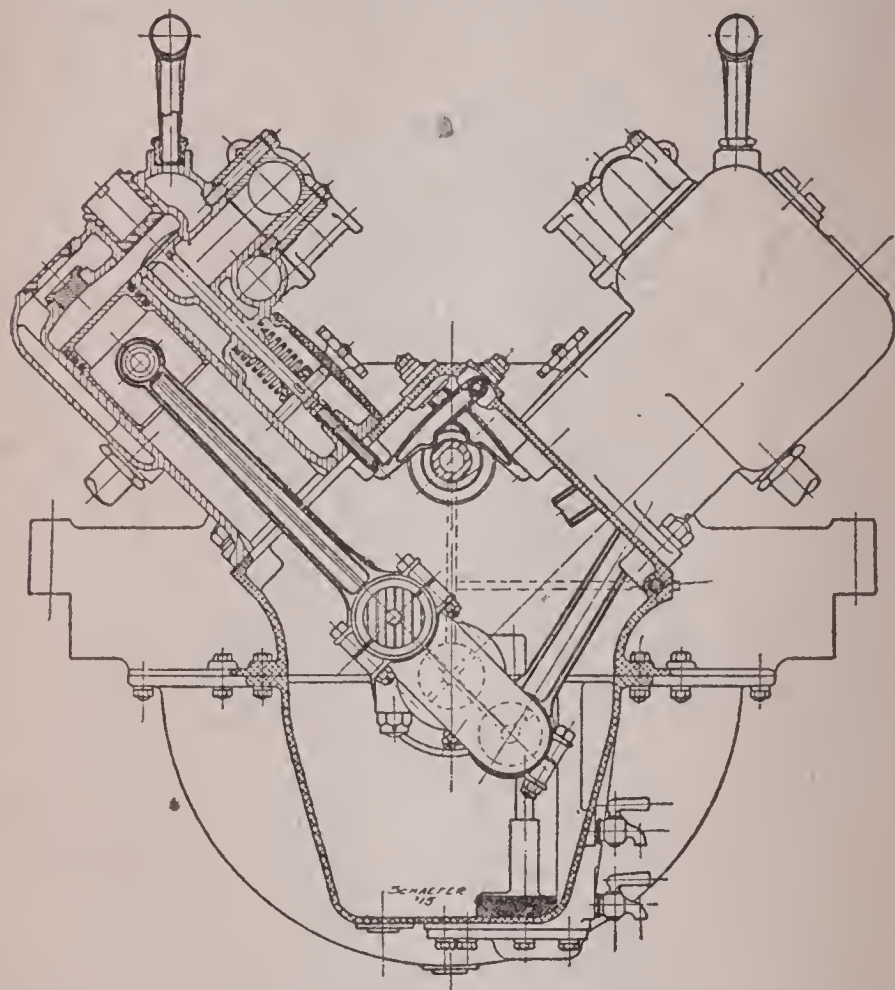


Fig. 12.—Sectional View of Eight Cylinder Engine.

connecting rods are of the forked type permitting the cylinder bloc to be set directly opposite each other. Each bloc of cylinders has its own water pump to maintain circulation, while lubrication is also by a pressure feed system.

THE KNIGHT MOTOR.

For some time the poppet valve motor, described above, was the only one which was com-

mercially successful. However, in 1908, Charles Y. Knight introduced a sleeve valve motor, manufacturing rights of which have been granted a

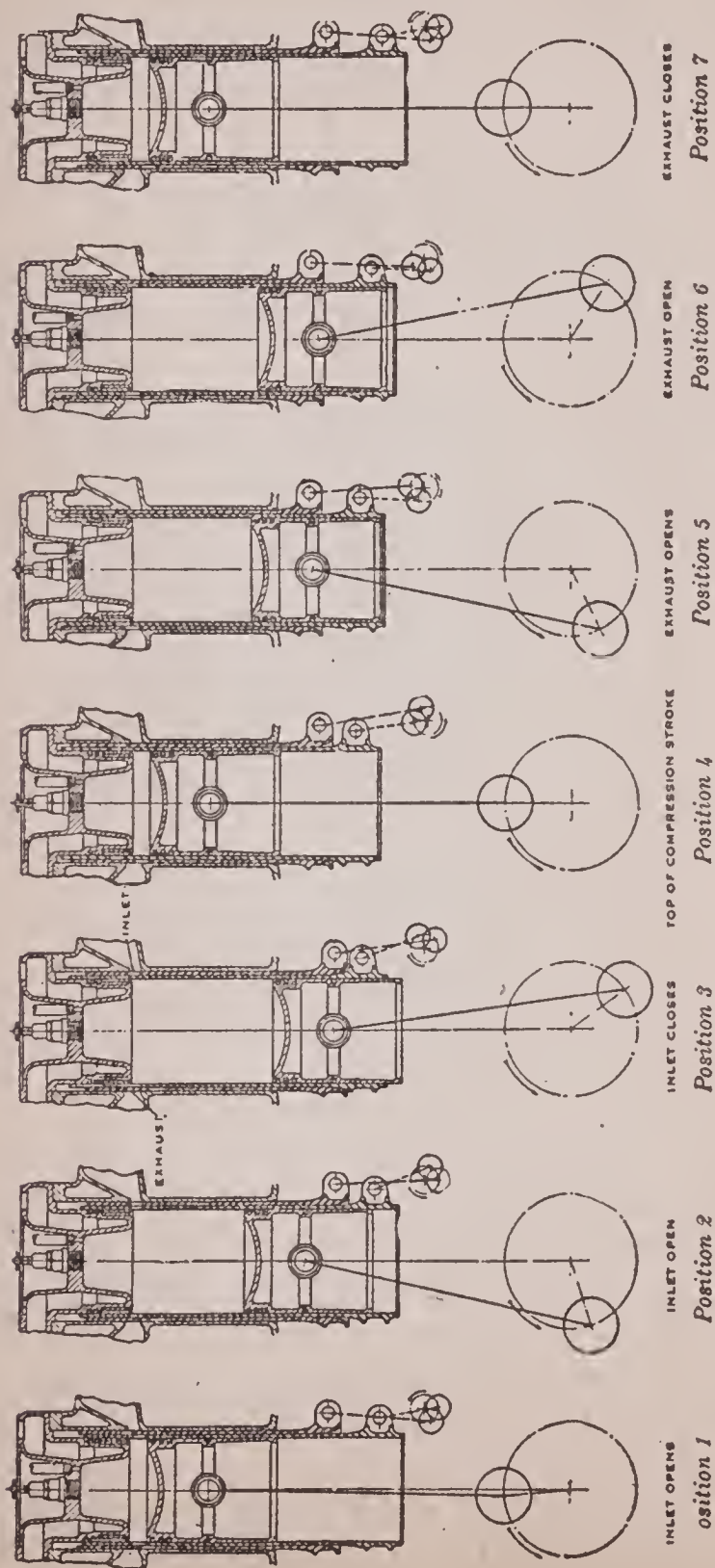


Fig. 13.—Inlet and Exhaust Timing Diagram of the Stearns-Knight Motor.

number of American and European motor car builders. In this Knight engine the valve functions are performed by two sleeves, one within the other, and both between the piston and cylinder wall. Fig. 11 illustrates this type. The cylinder head is of unusual construction and

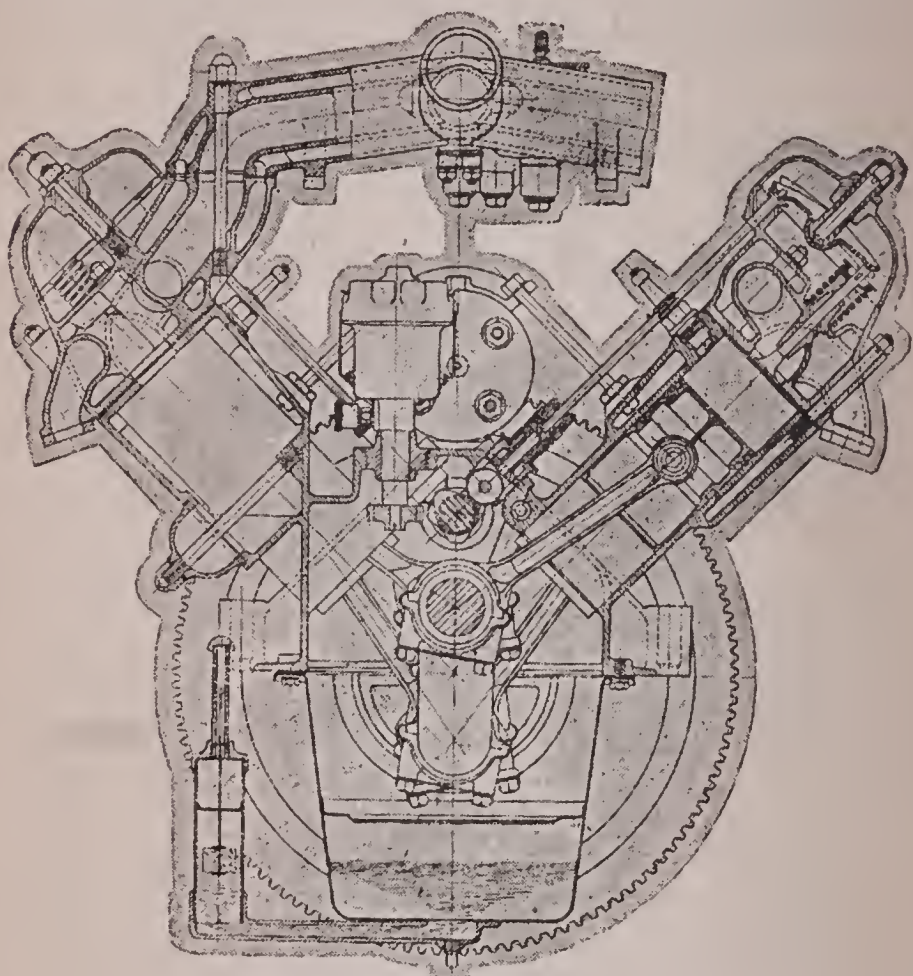


Fig. 14.—Cross Sectional View.

is made detachable. A part of this head extends into the cylinder bore for quite a distance, but is of a smaller diameter, so that the sleeves may work between it and the cylinder walls.

These sleeves, which replace the valves, are reciprocated by an eccentric shaft. This shaft has one eccentric for each sleeve which connects through short connecting rods with lugs formed on the sleeves at their lower ends. These

connecting rods are of two different lengths, as shown.

The movement of these two sleeves, which permit the gases to enter and escape, may be described as follows: Referring to Fig. 13, representing the timing of the Stearns-Knight engine. Position No. 1 shows the inlet starting to open, while position No. 2 shows the inlet open, in this case the outer sleeve has moved downward and the inner sleeve upward until the ports in both coincide. Position 3 shows the inlet closing, and 4 the top of the compression stroke. Position 5 shows the end of the power stroke and the exhaust begins to open, here the sleeves again bring the ports together, but in this case on the opposite side of the cylinder. By studying this illustration, the operation of a Knight engine can readily be understood.

Driving the Car

WITH the number of automobiles rapidly increasing the highways become crowded; therefore, in order to enjoy one's automobile, it is required of every driver to exercise a certain amount of caution.

We as automobilists have rights on the public road. These same rights envelop responsibilities to many users of the highway.

Some automobilists abuse their rights and heedlessly run over the rights of others. A wrong and a right will not make a right. Therefore some suffer for the wrongs of others. Each accident and wrong-doing on the highways has a tendency to arouse public sentiment against the motorist.

The responsible operators must take it upon themselves to control the irresponsible operators and show them that they must operate their cars without menace to life and limb upon the public highway.

Many drivers, usually through thoughtlessness, do not practice the consideration for others they should have. Many lives are in constant danger and accidents occur with the driver who takes a chance.

There is the driver who delights in exhibiting nerve stunts, such as remaining in the center of the road until almost upon the approaching vehicle, or the driver who will skid a car around instead of turning it as it should be done.

Many such foolish pranks have resulted into serious accidents, also causing the loss of life and limb.

LAW.

Traffic regulations have been adopted in all cities, and while touring through strange sections it is well to become acquainted with them. We all know that it is unlawful to be without lights after dark. Nearly all the states require lamps to be burned on both front and rear of the car from sundown to sunup.

ROADS INTERSECTING, AND TURNING INTO
ANOTHER ROAD.

It is wrong to drive a car across an intersecting road or highway unless your view is entirely unobstructed. Many automobilists will drive over a thoroughfare unaware of what may be approaching on the road which crosses it at right angles. The blame for an accident in this event is on the cautionless operator.

Turning into another road to the right, the operator should keep his car as close to the right-hand curb as possible. (Illustrated in Fig. 15.)

Turning into another road to the left, the operator should turn around the center of the intersection of the two roads (as in Fig. 16). Fig. 17 shows the wrong way to make a left-hand turn.

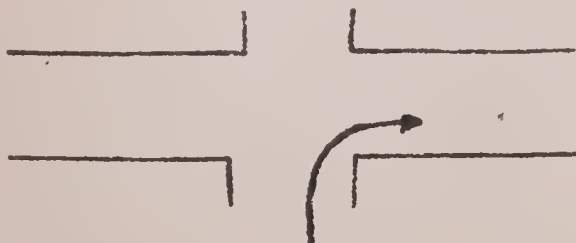


Fig. 15.

The operator of any vehicle who intends to turn or stop should always give the proper signal.

In passing over railroad tracks it is advisable to drop back into second speed, in which instance

you will avoid the possibility of stalling your motor on the track. Should you be compelled

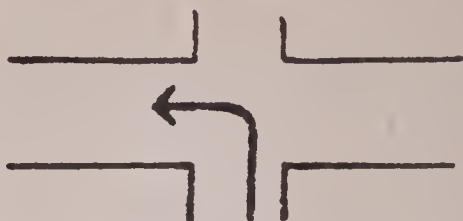


Fig. 16.

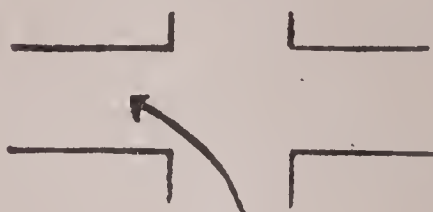


Fig. 17.

to unexpectedly drive ahead fast with your car in second speed your chances of escape are easier and more certain.

If you meet up with a frightened horse on the highway, drive your car to one side of the road and stop.

THE CHANGING OF GEARS.

Before moving the gear shifting lever from one position to another the clutch should be entirely disengaged. Unwillingness and laziness to change gears are the cause of many accidents and often very destructive to the car.

At the proper time, instead of a driver changing back into second speed, many allow the car to drift along until caught into a tight place in the traffic, resulting often in an accident. Use the second speed as often as necessary; it was installed in automobiles for good purposes; make use of it. We should never be in such a hurry that we cannot spare a few seconds for safety. You often hear the remark, "He lost control of the car." Indeed, the driver in most all cases loses control of himself and not of the car. One is not an

expert driver until he intuitively performs the operations which control the car, just as one walks or reaches out for an object.

SKIDDING.

Skidding, a most dangerous element of motor-ing, is a helpless situation. It remains for the driver not to become confused to apply the brakes.

Skillful handling of the steering wheel might in some instances prevent an accident from skidding. Reduce the speed of the motor, turn the front wheels in the same direction that the car is skidding, and don't apply the brakes.

If the front wheels skid, turn them in the opposite direction from which they are skidding.

CROSSING STREET CAR TRACKS AND CLIMBING OUT OF RUTS.

Skidding can be prevented, accidents can be avoided, and the life of your tires lengthened if you will learn how to turn your car out of street car tracks or ruts. Make a sharp turn of your front wheels. Do not allow the wheels to climb along the edge of a rut and finally jump off suddenly. And do not attempt to climb out of these conditions at speed. Haste surely makes waste in driving an automobile.

WATCH YOUR CAR CLOSELY.

You will soon become accustomed to all the sounds your car makes. Any other sound, be it ever so slight, will be immediately perceptible. A good driver will immediately locate the cause for that new and strange noise. It is the warning signal that something is not normal. It may be a loose nut. It may be a cry for grease. Do not disregard these signals. Locate the cause and give them immediate attention. Thus you will lengthen the service of your car.

DRIVING OVER ROUGH ROADS.

Keep the motor pulling your car slowly over rough roads. Thus it keeps everything taut and lessens the shock and jar that the car gets through bumping over ruts.

COASTING DOWN HILL.

In coasting down hill use the motor as the brake. That is, close your throttle and let the car drive the motor. This, of course, will not be sufficient to hold the car on very long and steep grades. It will serve, however, to relieve the strain on the brakes, and it will enable you to keep the car under absolute control.

If the grade is long and steep, use the foot and emergency brakes alternately. This will prevent them from burning out.

A CAR'S SERVICE DEPENDS UPON THE DRIVER.

Much of the satisfaction that an automobile gives depends upon the driver. If he neglects his automobile, if he does not lubricate it, or if he tinkers with it too much, he is bound to receive unsatisfactory service.

No machine can be absolutely automatic. All things must wear in time. The best preventive of wear, and the most certain thing for increasing the life of an automobile, is proper lubrication.

Familiarize yourself thoroughly with all the lubricating points of your car. Make the lubrication of your car as regular as is the eating of your meals. If you do this, you won't have any complaint to make of your car becoming noisy or of bearings wearing out. If you don't do it, you will not get the satisfaction from your car that you had expected.

OPERATE YOUR SPARK LEVER.

The spark lever is to be retarded whenever the

motor labors or pounds. In driving over rough roads, through sand and mud, or up hill, or whenever there is a heavy load and the motor does not seem to run smoothly, retard your spark.

Driving Pointers

DON'T OVERLOOK THE SPARK.

Many drivers entirely ignore the spark. As a result their motors do not give perfect service, and some cause considerable trouble.

COASTING MOUNTAIN ROADS.

Whenever you approach a long and steep grade, it is best to put your gear speed lever into first speed and allow the car to drift down on the motor. This is better than using the brakes. It gives you absolute control of the car at all times.

COASTING WITH CLUTCH OUT.

There is a satisfying sensation in allowing the car to coast along with the clutch disengaged. But do not under this condition, if the car is speeding, let the clutch in when the motor is running slowly. It produces too severe a shock on the entire driving mechanism. Speed your motor up to as great or a greater speed than the car is traveling, so that the shock will not be so severe.

In all cars such a plan of driving results in strains, often so serious that the transmission is wrenched from its anchorage. The clutch is damaged, and accidents have resulted.

KNOW YOUR CAR.

Your satisfaction will be greatly increased if you will learn the details of your automobile. Learn to make the simple adjustments. Do not depend upon some one else to do that which is so simply done, and which you can get such satisfaction in doing.

THE COST OF SPEED.

The law is just as immutable in that it collects a greater cost for speed in a motor car as it does of any machine or of man. If you run fast, if you work hard, you require more food to sustain you. If you drive your car at a fast speed all the time, it requires more fuel—more gasoline and more oil.

If you work fast and hard, you wear out more quickly, and so does an automobile.

Tires, for instance, last twice as long on a car that is driven at fifteen miles an hour as they do upon cars that are driven at thirty miles an hour.

Remember that the service your car gives you is as much dependent upon the manner in which you operate it as is your own health dependent upon the manner in which you care for it.

THROUGH SAND AND CLAY.

Heavy sand: Deflate tires, but not to a degree dangerous to the rim. Use chains. Pump up tires immediately after passing through sandy stretch.

Soft clay, etc.: Do not deflate tires. Use loose chains. In very bad places at times when no friction is gained, do not spin the driving wheels as this only enlarges the hole and increases the trouble. Jack up car first, then fill in the rut or hole that has been made. Most trouble occurs on the off-side of the road. Keep to center as much as possible.

DO NOT DRIVE IN RUTS.

Driving in ruts is not only bad for the tire, but it is equally bad for the highway. It is only the lazy driver that "sticks" in the ruts rather than being awake and on his guard to avoid them.

Continued driving in one line or spot quickly eats through the top dressing of the macadam

road and wears the hole or rut in the body of the best road. This is the difficult damage to patch, without renovating almost the entire roadway, and motorists should be glad to co-operate to this extent in keeping good the better highway. *Do not drive in ruts.*

DON'TS.

Don't strain your motor through laziness of shifting into a lower gear. Serious results occur from forcing the motor on steep grades and heavy pulls in the high gear.

Don't drive in car tracks, especially on wet pavements. Many accidents occur to motorists who haven't been able to get their car from the rails when suddenly and unexpectedly required to do so.

Don't take chances of looking through the wind-shield or celluloid curtains while same are covered either with rain or snow. Always stop and clean off.

Don't forget that sometimes the pedestrian who would walk in front of your path may be some unfortunate blind or deaf person.

Don't be inconsiderate to the pedestrian on the walk by splashing him full of mud. It is easy enough to slow down or drive to one side of the road a trifle, thereby omitting this offense.

Don't test your automobile in the busy thoroughfares. After you have finished your work, drive out to some roadway where you will be free from pedestrians, traffic, etc. Many drivers and repairmen who work for garages centrally located often meet with accidents because after having made a quick and hurried repair they drive out in the down-town district, crowded with people and traffic, to determine the results of their work or test out the car.

Don't drive on in case of an accident.

Don't fail to be a gentleman under any provocation.

Don't exhibit grandstand acts by driving upon a crowd of people and suddenly opening the exhaust cut-out, at the same time racing the motor, or by skidding around instead of going back and forth until you have made a complete turn. Remember that while the automobile is flexible, powerful and easily controlled, you may make a slip.

Don't drink if you intend operating an automobile. Many accidents occur to automobiles driven by intoxicated operators.

Don't ever get rattled.

Don't try to race every car which passes you.

Don't drive your car on car tracks; it is an expensive luxury.

Don't drive fast around corners, as this will cause side strain and a grinding wear on the tread of tires.

Don't pass a street car while it is at a standstill. Passengers often alight without looking for any approaching traffic. Stop still until the street car is again in motion.

Don't try and dodge an excited pedestrian in the street. He or she will go back and forth much confused and finally run directly in front of your machine. Stop as quickly as possible, because in many instances it has proven to be either an intoxicated person or the one who thinks "Hit me and I'll sue you!"

Don't stop to argue with drivers of teams, trolley car motormen, etc. It often occurs that the other fellow is ignorant of your rights, and persistence on your part may some time result in an accident.

Don't forget that vehicles do not have the right of way at street crossings.

Don't curse police officers. We should all cooperate with the police force to assist in reducing

the number of accidents caused by reckless driving. Careless pedestrians, particularly those in congested districts, lack attention in crossing streets. It is your duty as a citizen to understand the rules and regulations of "street traffic," and especially those rules concerning the community of which you are a resident. A definite knowledge will aid materially in causing traffic conditions to steadily improve.

Don't pass another car with the intention of lingering after you have passed, whereby they receive, in return for their kindness in allowing you the right of way, your dust. Either pass them, maintaining your passing speed, or continue to drive far enough ahead until you have reached such a distance that burnt oils and gases discharged from your car, together with the germ-filled dust, won't interfere with the following car.

Don't travel over unknown roads at a break-neck speed, for a little "thank-you-marm" might set you in the flowers.

Don't be a road hog because you have a smaller car or because you don't care to drive any faster than the speed you are traveling at the time. If another car is desirous of passing you, keep to the extreme right of the road until same has passed; then, if your roadway is again clear, return to your former position on the road, driving along at the speed which you care to maintain.

Don't neglect to test batteries.

Don't leave your car with motor running.

Don't stop your car on the wrong side of the street.

Don't fail to always release hand-brake before attempting to start.

Don't start out on a trip without attention to oil, gasoline and water.

Don't throttle your car in jumps, as this is very injurious to working parts.

Don't ever drive faster than the law permits; it will save you many a fine.

Don't fail to keep brakes properly adjusted; it is more important to stop a car than start it.

Don't use the electric starter continuously to demonstrate its operation unless you in turn run the motor sufficiently to recharge the storage battery.

Don't forget to see that your gasoline tank is full before starting out on a long trip. It is much more convenient to fill the tank at a garage than when on the road.

Don't put acid in the jars of the storage battery to raise the specific gravity, unless the electrolyte has been spilled out, and it becomes necessary to mix up a new solution.

Don't forget the automobile is one of the finest pieces of machinery manufactured, and you will be repaid in excellence of service many times for the proper care and attention you give it.

Don't run on the dry battery unless the magneto circuit is somehow impaired. It is much easier to start on the dry battery circuit, and it should be kept in order for this purpose.

Don't fail to put a small quantity of distilled water in the storage battery occasionally. Water will evaporate, but acid will not. If the solution evaporates so that the wood separators are exposed to the air, they will be completely burned up by the acid and new ones will have to be installed.

In laying up your car for two months or more, jack it up clear of the floor, allowing the axles to rest on supports. Allow all air to escape from tires except enough to shape them.

Because rust eats into the fabric, rims should be sandpapered and painted preferably with graphite. Paint or any other rust preventive will do.

The Care of Tires

THE "REASON WHY" OF THE PNEUMATIC TIRE.

THE pneumatic rubber tire is especially adapted to the automobile, because of its resiliency (something akin to the "bouncing" properties of a rubber ball) which enables it to absorb the shocks caused by the unevenness of the road surface.

This combination of air and rubber—the two most elastic substances in existence, is ideal for the purpose, forming an efficient cushion, yet sufficiently strong and wear-resisting to carry the heavy weight of the car and its occupants over the worst kind of roads.

But rubber alone is not enough; it needs air and plenty of it. Air is so cheap, there is no excuse for rim-cutting or other similar troubles which are caused by under-inflation.

PRINCIPLES OF TIRE CONSTRUCTION.

An automobile tire is something more than a mere tube of rubber with air inside it.

To build a tire with the requisite combination of strength and resiliency requires a combination of skill and experience such as is demanded of few other items of automobile equipment.

A strong tire alone would be easy. Steel is strong. A tire would be resilient if simply made of rubber alone, but would not wear. Hence the combination of rubber and fabric with which we are all more or less familiar.

To hold the tire on the rim, some kind of "grip" is required so that a complete tire casing consists essentially of a rubber outside, a fabric "carcass" and beads or grips to hold it in place.

The fabric is in itself the subject of special study.

Not every kind of fabric is suitable for tire purposes, and after many years of experience with materials of all descriptions, the only one found to possess the requisite qualities has been sea island cotton, of which, however, only the very finest long staple grades can be used.

At every stage of its manufacture, the material is carefully examined and the least defect is sufficient to cause its rejection. When received at the factory it receives a final rigid inspection and is then ready for the friction calendars. Here it passes through heavy steel rolls and is thoroughly impregnated with rubber.

Next, it is carefully cut into strips on the "bias" of the material, this being necessary for the proper distribution of the stresses evolved in running over the entire body of the tire.

This having been done, it is ready to build up into the tire itself.

TYPES OF TIRES.

The various plies of fabric having been previously frictioned and cut into strips, are carefully laid one upon another, on a form, care being taken that each layer "breaks joint" with the one below.

The first plies are slightly wider than the succeeding ones, for a reason which will be presently seen.

The requisite number of plies having been laid, the next processes are the applying of the side walls and beads. These beads are made of a harder compound and, having been laid in place, the first plies of fabric are carefully tucked in around so that the beads are firmly held in place.

Each succeeding layer is firmly rolled down onto its predecessor. Next a thick "cushion" layer

of rubber is applied, then the "breaker strip," and lastly the tread is applied. This is much thicker than the side walls and is a specially tough compound suitable for withstanding the heavy wear and tear of the road. The function of the breaker strip is, firstly, to reinforce the tread, and, secondly, to act as a warning signal that the tread is getting worn out and the tire needs renewal or retreading.

In its essentials, then, a tire resembles a shoe, the fabric standing for the lining, the side walls for the uppers, while the sole of the shoe is replaced by the tread. Just as these three parts are of varying strength in the shoe, so they are in the tire, each carefully proportioned to the work it has to do.

Conforming in general construction to the regular lines already mentioned, it differs from other types mainly in the fact that the beads are made of rubber alone, and while firm enough to hold rigidly in place, are yet sufficiently flexible to allow removal from the ordinary one-piece (or clincher) rim.

The only point of difference between this tire and the quick detachable type is the bead construction.

In the quick detachable tire the bead is stiff and inextensible, the removal of the tire being effected by removing side, a rim which is made detachable and held in place with nuts and bolts.

The ring being removed, the tire easily slides off, and is just as readily replaced.

The straight bead type of tire has some followers, but little different in construction from the ordinary clincher type, the change again being in the bead. In this tire the projecting bead of the clincher is absent, being replaced by a special form which depends for its grip on the pressure

of numerous strands of fine wire embedded in the rubber.

Being used in a straight-side rim, the air space is slightly larger, while the rounded edges of the rim obviate any tendency to rim-cut when the tire is run "flat" (that is, empty), a practice, by the way, which cannot be too strongly condemned.



Fig. 18.

This tire cannot be used on a clincher rim, but may be used on an ordinary quick-detachable rim by simply reversing the flanges.

CORD TIRES.

Two layers of these cords are applied one over the other in the following order :

First a layer of pure rubber is applied to the form. Next a series of staples, 300 in all, are set at short stated intervals around the inner edge of the bead and on these the first layer of cords is laid by a machine, which places each cord accurately in its appointed place, giving it at the same time the requisite amount of tension.

When the first layer is completed, a second layer of rubber follows, then another of cord. A third cushion layer of rubber follows, finishing with breaker strip, tread, side walls and beads as in the other tires.

It is worth noting that in the process of manufacturing the cords each is twisted up of 24 separate threads, the threads themselves being thoroughly impregnated with pure rubber both before and after twisting.

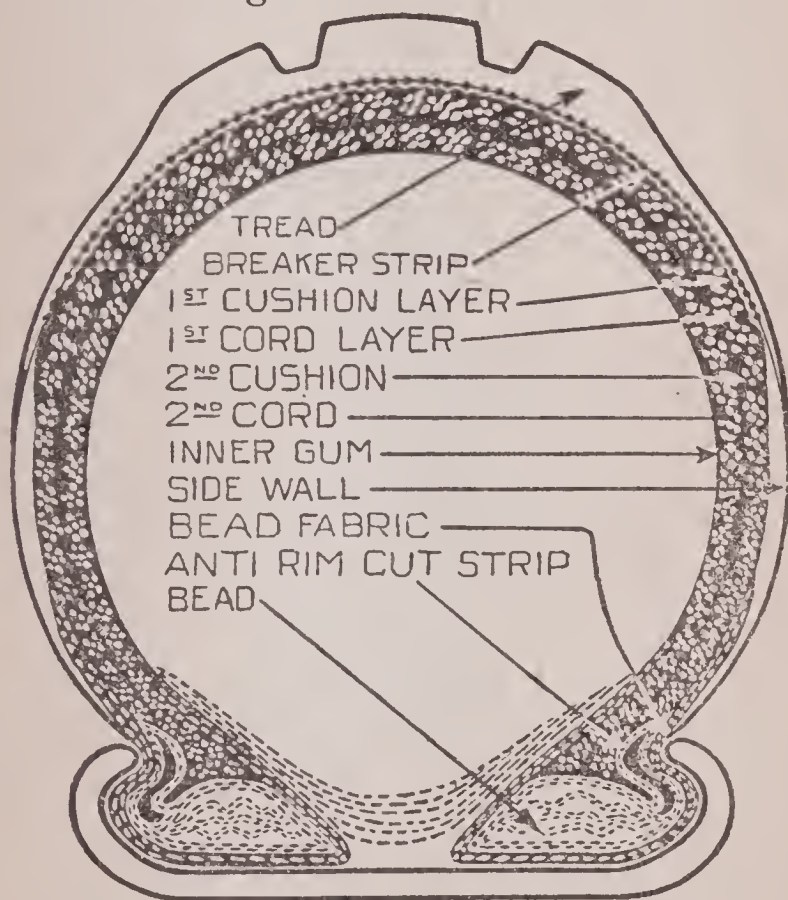


Fig. 19.—Goodrich Cord Tire.

The great strength of this form of construction lies in the fact that each cord forms a separate unit, distributing the strain and blows of the road over the entire body of the tire, that it is more resilient because less rigid than a fabric tire and is more easily repaired.

Although of lighter construction than a fabric tire, it is for these reasons really much stronger.

THE INNER TUBE.

The inner tube has not been inaptly termed the "heart" of the tire. It is necessarily made of the best procurable quality of rubber, since it must withstand the heavy pressure demanded while at the same time preserving its elasticity.

In making a tube, the rubber is first rolled into sheet form, then wrapped layer after layer on a steel mandrel, each layer being carefully rolled

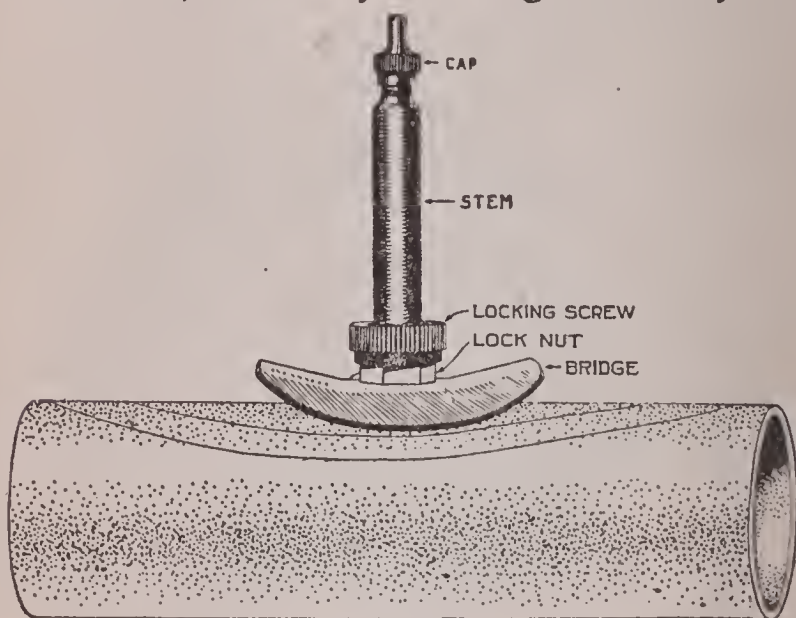


Fig. 20.

down on the preceding one until the requisite thickness is attained.

After curing, the tube is cut to the requisite length, the ends buffed and spliced, and it is carefully tested for possible defects before packing for shipment.

The illustration shows a small section of an inner tube with valve in place.

THE CARE OF TIRES.

Some owners run the year round without a single trouble, getting more enjoyment out of an old runabout than another man from his high-powered, six-cylinder, all up-to-date-and-a-bit-over auto of the most expensive build.

Maintenance is largely a matter of care and attention.

If you don't feed and groom a horse regularly, he soon gets out of condition, yet the car goes out into the rain, over the worst kind of roads.

In the matter of tires alone, over 75 per cent of the user's troubles arise from misuse.

"Neglected trifles" is a fair summary of the whole question.

Look over your tires today. Ten to one you will find at least one or two cracks or pinholes, apparently not amounting to anything at all. But! Clean one out carefully and follow it up. It extends right down to the fabric, and every time that part of the tread touches ground the tire is one more stage on its way to the "graveyard." Wet and sand find their way in until at last the tread blisters or peels off bodily.

An ounce of prevention is worth a ton of cure, and frequent overhauling of your tires and the immediate repair of even the smallest cut will materially help to lengthen the life of the tire.

Here is shown a tire that has blown out, due to neglected repairs. It originally had a small cut entirely through. An inside patch was applied by the owner, he feeling that this was all that was required to place the tire in good running order, but instead, the inside patch merely aggravated matters and, acting as a wedge, caused the tire more harm than good. The result, as shown in the picture, was that the tire blew out from bead to bead, that is, the inner patch wedged the fabric apart, causing it to break or pull apart from bead to bead.

By looking closely you can see how the patch has pulled away from the position it originally held, and has been forced through the break, protruding on the outside. (Shown in Fig. 22.)



Fig. 21.—Blisters Caused by Neglected Cuts.

We class this a condition due to a neglected repair, as it does not follow from any weakness in the tire, but has resulted from the tire not receiving the proper attention when it was first cut.

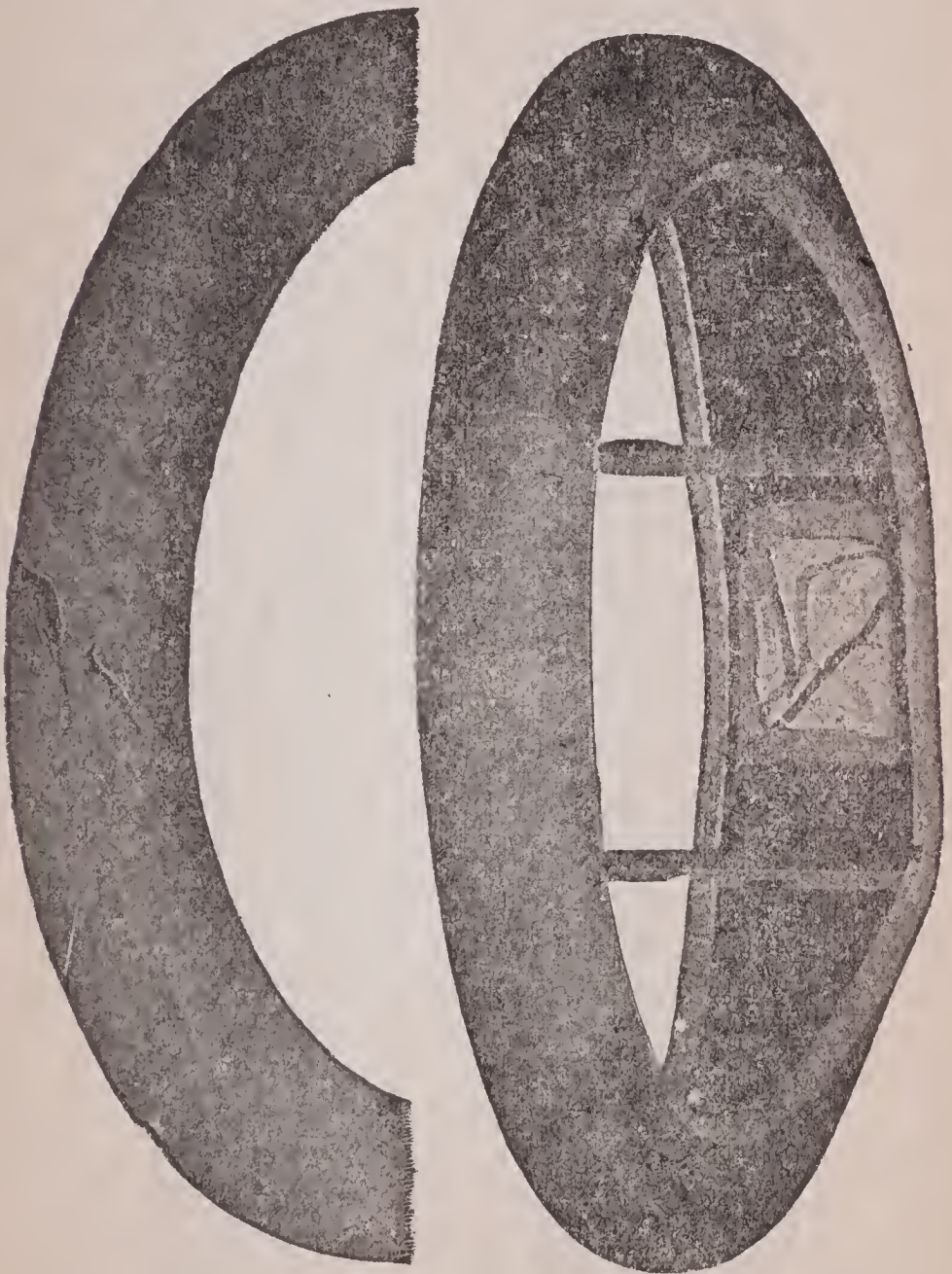


Fig. 22.—Blowout from Neglected Repairs.

UNDER-INFLATION.

Under-inflation produces over-heating. This in turn saps the life of the fabric in the tire, destroys the cohesion between its various plies,



Fig. 23. — Result of Under-inflation.



Fig. 24. — Effect of Running Out of Alignment.

and allows the tread to loosen up all round. If the injury were confined to the latter only, it could be repaired by retreading. The cost of this would be approximately one-third the original cost of the tire and the ultimate mileage would be reduced. So the penalty of running under-inflated is costly. On the other hand, where the plies of fabric separate, repairs cannot be made at all, and the tire if cut through or broken by a stone-bruise is worth only junk value.

Another point worth considering is the much talked of "rim-cutting." No tire will rim-cut if it be properly inflated, but any tire will be irretrievably damaged by being run ever so short a distance in a deflated or even partly deflated condition.

RUNNING OUT OF ALIGNMENT.

This and many other tire troubles are clearly the fault of the driver and should never occur if the tires are properly cared for and small repairs attended to at once.

A common source of tire trouble is premature wearing out of the treads, from the wheels being out of alignment. This is generally a condition of the front wheels, though it may affect the rear wheels. It can be easily located by measuring the distance between the two wheels with a stick, both ahead and behind the axle. The effect is to grind off the tread and ruin the tire. In aggravated cases, the damage may be complete in a hundred miles. The remedy is to have the alignment corrected and the tire re-treaded, if it is otherwise in good condition. A very similar result is produced by a wheel out of true or wobbly, the wear appearing at fixed intervals around the tire.

Any cut which reaches the fabric ought to be repaired with a vulcanized patch. If small, it can be sealed with a plastic compound, which keeps

out moisture and dirt. It may not hold in the larger cuts, however, and these should be vulcanized.

There are a number of handy portable vulvan-



Fig. 25.—Tread Worn Off by Skidding.

izers in the market which, if properly used, are all right for the average tread cut. Too large a repair should not be undertaken with them, as the necessary pressure for such cannot be secured.

Great care should be exercised lest you burn the tire, for the heat is difficult to control in these small vulcanizing devices. To some extent this tendency can be overcome by putting a sheet of

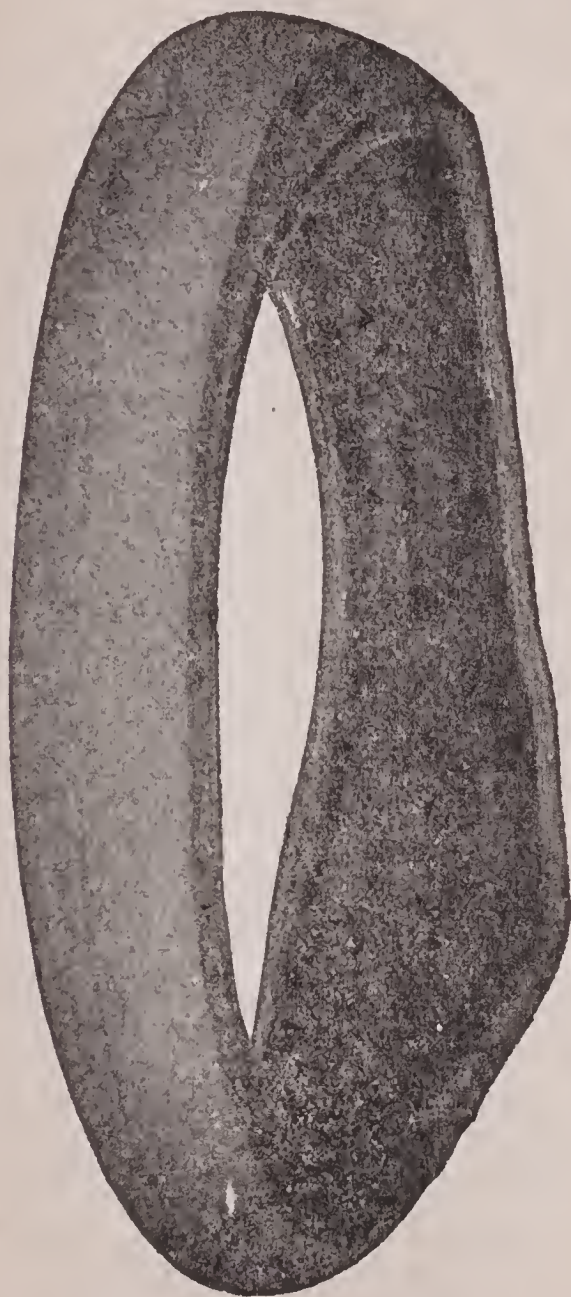


Fig. 26.—Fabric Destroyed by Inner Liner.

paper between gum and vulcanizer. They are, however, more adaptable to tube repairs, which with a little experimenting can be worked out very nicely.

Judgment should be used in applying chains. These should always be adjusted loosely so that they strike the ground ahead of the tire. In this way the maximum non-skid effect is produced

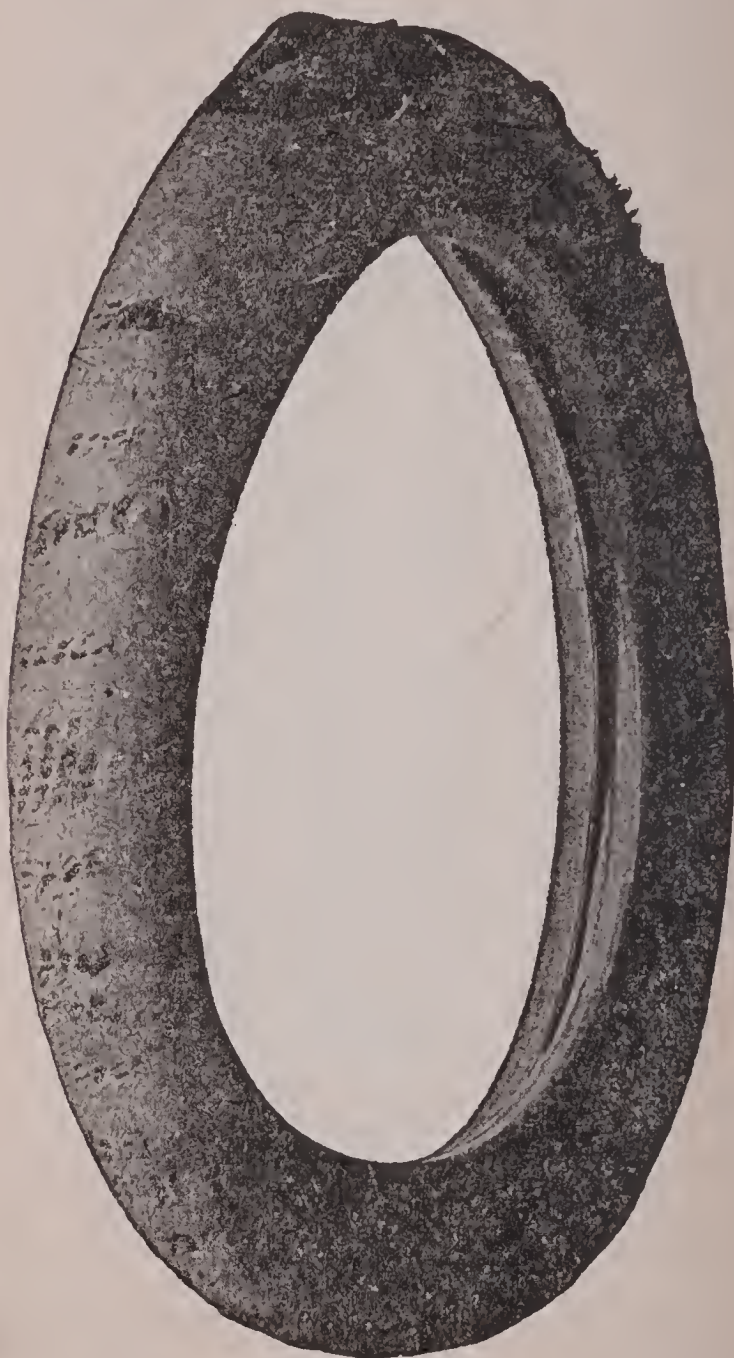


Fig. 27. Cut and Torn by Improper Use of Chains.

and they do not bind and tear the tire as they would do if adjusted without plenty of play.

Avoid locking your wheels with the brakes. No

tire will withstand the strain of being dragged over a pavement in this fashion. The heat will burn it through in a few seconds if the speed and load be enough. Besides, the danger of accident from a skidding machine is increased. Let the brakes do the work of stopping the car, by proper application. Do not put this work on your tires.

The strain caused by the sudden stopping of a 2,000 or 3,000 lb. car, running at 20 or 30 miles an hour, is really tremendous, and no amount of human ingenuity can ever invent a material capable of withstanding such a shock. Steel itself would be disintegrated in time by such treatment. Heavy loads and excessive speed have the same tendency, the initial cause of which is the intense heat generated inside the structure of the tire itself, destroying the resiliency of the rubber and making it brittle and non-elastic.

Do not use too much soapstone inside your cases. This will accumulate at one point, friction will be set up, and the tube will soon be honey-combed with small blisters, presenting a bubbly appearance.

Keep away from inner liners in new or serviceable cases. They may extend the life of old and worn-out tires by an additional 500 miles or so, but they will ruin good tires through the frictional heat engendered.

Stone bruises are not an infrequent trouble. Let us say at once, these are the motorist's own fault.

Any one who deliberately drives over a heavy stone or similar obstacle is literally asking for a blowout.

The reason is that the effect of a heavy car at a high speed, striking a stone, is just the same as that of a heavy missile hitting the tire. Something has to give way, and this is usually the fabric.

Sometimes this injury does not become known for a long time, but sooner or later a blowout is inevitable.

Running in ruts or car tracks is another easy way of spoiling a tire.

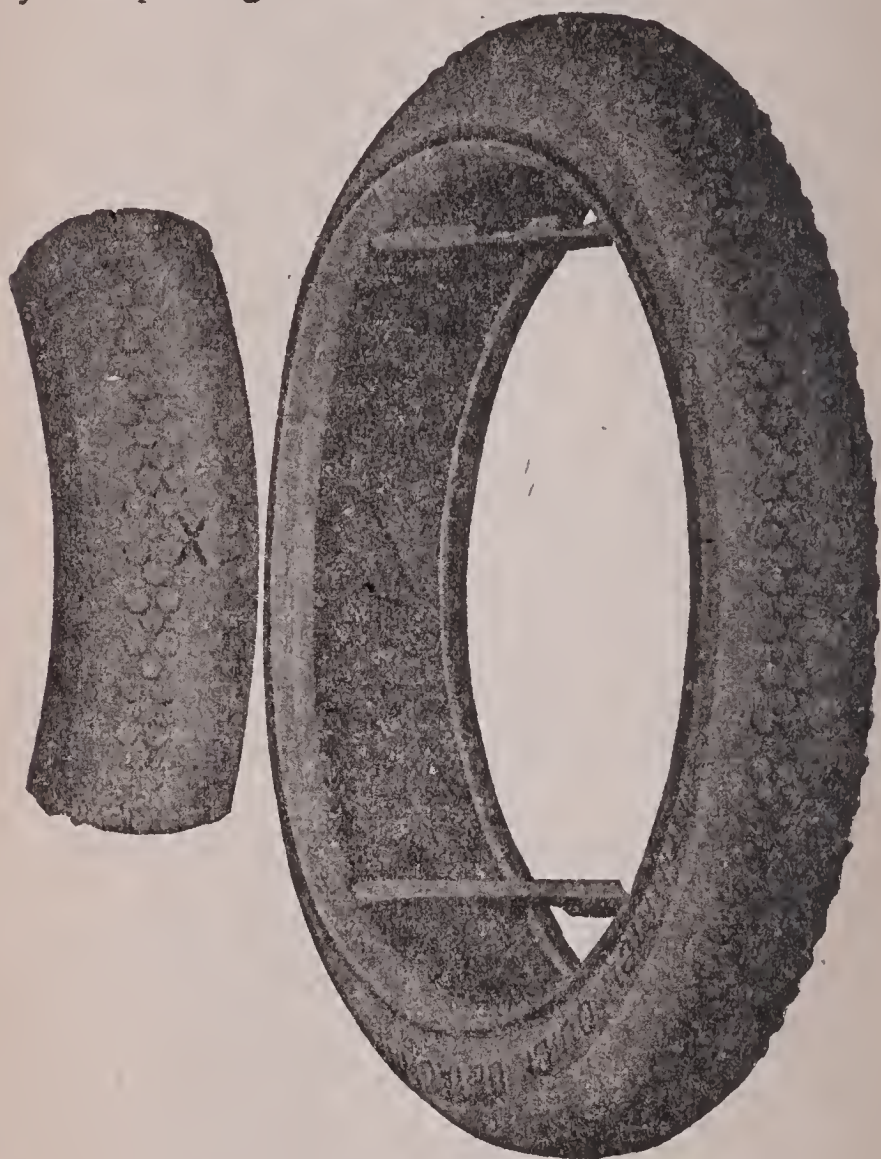


Fig. 28.—Fabric Broken by a Bruise.

The tread is like a boot sole, made for hard wear, but the side walls may be compared to the boot uppers. The result of running in the manner indicated is to wear off the sides, which are speedily ruined, although the tread may be intact. This kind of injury is almost impossible to repair, so every care should be taken for its avoidance.

The foregoing are some of the more common causes of tire trouble. All of them may be avoided by a little care and attention to common sense rules.

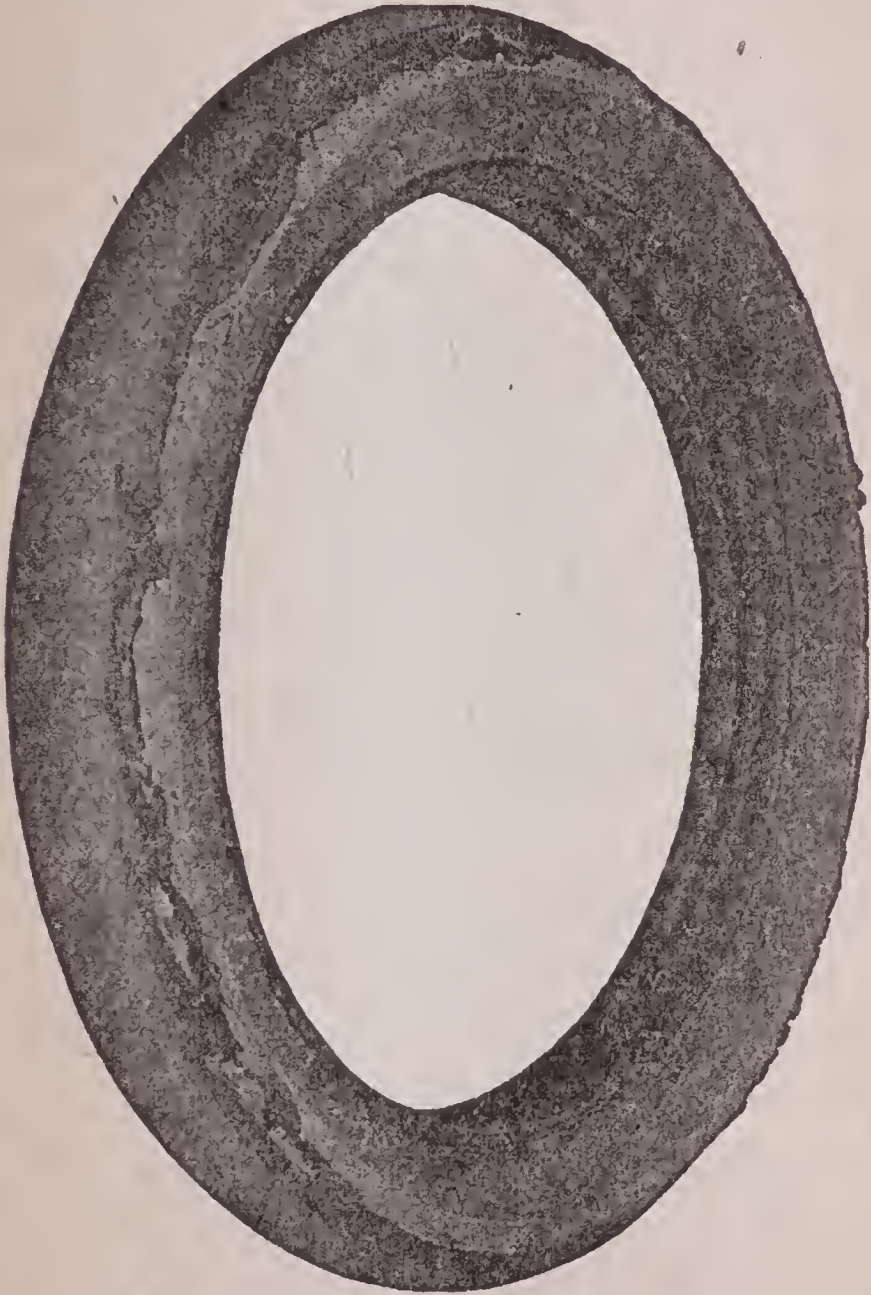


Fig. 29.—Effect of Running in Ruts or Car Tracks.

Reckless or careless driving cannot be too severely condemned. Even if no accident occurs, it is utterly destructive of both tires and machinery.

HOW TO TEMPORARILY REPAIR AN INNER TUBE.

Inner tube must be removed from casing to repair puncture. If puncture is invisible, immerse inflated tube in water. Air bubbles will locate trouble.

For quick and handy roadside repair, use patches, as shown in accompanying illustration.



Fig. 30.

When using patches, select the required size of patch. The surface around puncture in the tube should be roughened with coarse emery cloth or metal buffer. Cover the roughened surface of the tube around puncture with cement, applying



Fig. 31.

three coats at intervals of about five minutes. Allow this surface to dry until the treated surface is quite sticky to the touch. This requires about twenty minutes from the time the first coat of cement is applied to the tube. Press patch down firmly. Spread some French chalk over the repair to prevent it sticking to the casing.

Before replacing the tube allow a short time to elapse for perfect adhesion.

Before replacing the punctured tube, examine the inside of the case carefully, and remove the



Fig. 32.

cause of the injury (in most cases a tack or small nail). Often this can be located only by a minute examination or by passing the hand inside of tire.

When using Quick-Detachable Clincher or Straight Side tires, see that the flap is properly adjusted before placing tube in casing. A pinched tube will cause a tube blow-out.

Note.—Place the tube in the hands of a competent vulcanizer at the earliest possible moment for a permanent repair.

A TEMPORARY REPAIR TO CASING.

If the puncture has been caused by a thin nail, use an Emergency Tire Saver Patch, which is coated with rubber on one side. First clean the inside of the casing thoroughly with gasoline and roughen with emery cloth, then apply two or three coats of Dry Patching Cement, allowing each coat to dry until it is quite sticky to the touch.

Then remove the wax paper from the emergency Tire Saver Patch, moisten with gasoline, and apply to the inside of casing.

Even when the hole has been made by a blunt obstacle, such as a thick screw, an Emergency Tire Saver Patch, applied as stated, will make an effective temporary repair.

After the Emergency Tire Saver Patch has been applied, *do not neglect to freely sprinkle both patch and space about it with Tire Talc.* This



Fig. 33.

is to prevent adhesion of the tube to the repair.

In case of a large cut or blow-out, use an Inside Blow-out Patch and Hook-on-Boot or Lace-on-Boot, thereby preventing sand and water from working into the tire and caus-

ing more serious injury to tube and casing. The flaps of the inside blow-out patch are locked around the bead of the casing and require no cement. The Hook-on-Boot is placed over the casing while deflated and hooks in the rim. When Lace-on-Boot is used it is placed on the outside and laced around the tire, rim and felloe of the wheel.

Tire Tape is an essential part of a repair outfit. Every motorist should carry a roll.

Note.—Put the casing in the hands of a competent vulcanizer at the earliest opportunity.

PUNCTURES.

There is no hard and fast rule for avoiding

punctures. But you *can* keep a puncture from ruining the whole tire.

Don't run on a deflated tire.

If you are unfortunate enough not to have demountable rims or even a spare casing or tube, stop short. Better take off the tire and run a short distance on bare rim, than continue on a deflated tire.

BLOW-OUTS.

Blow-outs can be traced to a number of causes.

You may have bruised your tire last week, or last month, and even though the tread shows no sign of being injured, the inside fabric was broken and every revolution after that weakened the fabric, and a blow-out follows.

Overloading puts too much extra strain on the tire—a blow-out may result.

Under-inflation places a strain on the tire by bending the sidewalls and breaking the fabric. This never occurs if tire is properly inflated.

CUTS.

Watch for cuts in the thread.

Don't neglect the small, apparently unimportant ones. They will not remain unimportant.

Water will enter through cuts and rot the fabric. Sand and grit will work in between the rubber and the fabric, and in a short time will loosen the tread.

Examine the treads from time to time.

Large cuts, particularly where fabric is injured, should receive the immediate attention of the repair man.

BRUISES.

Examine the inside of your casings from time to time for bruises.

A sharp blow from road obstructions, car tracks or curbing will bruise a tire, and may fracture

the fabric inside the casing. You cannot locate a fracture of this kind on the outside of the tire.

The casing with fractured fabric should receive the immediate attention of the repairman.

CHAFED SIDE WALLS.

Avoid driving in car tracks, against curbs or in deep ruts, as it chafes the rubber on the side-walls of a casing.

In order to give flexibility the sidewall compound has a much higher proportion of pure rubber than the tread, and consequently will not stand as much abrasion.

A badly worn sidewall permits water to enter and rot the fabric.

DON'T RUN ON DEFLATED TIRES.

If you run a tire deflated, the grinding and crunching between rim and road will speedily ruin it.

EXAMINE RIMS.

Be sure your rims are clean and true. Dents or irregularities in your rims often cut or chafe the sidewalls of the tire. This permits the entrance of moisture, and decay is sure to follow.

A little attention to your rims may save many bills for tire repairs.

UNDER-INFLATION.

Tires are made to carry certain loads and withstand ordinary strains—but to do this the tire must be pumped up to the required pressure.

When you use less than the proper amount of air the casing itself must bear more than it was built to carry. Result: the length of your tire service is materially reduced.

Further, the constant bending of fabric when running tires soft, causes overheating and tears

the layers of fabric apart. A blow-out will follow.

An air-pressure gauge will enable you to know when your tires are inflated to the proper degree. Don't trust your eyes, but get a gauge.

OVERLOADING.

The strain of extra weight will fracture the tire fabric in a short time.

If you are accustomed to carrying more passengers or heavier baggage than your tires are intended to stand, *equip your car with over-size tires.*

More air capacity alone does not make an over-size tire; real over-size is obtained by thicker treads, and heavier sidewalls—heavier construction throughout the tire.

CHAINS.

Chains and other tire-destroying metal devices will materially lessen the life of a tire.

They will cut through the tread, and often through the fabric. Water will enter the breaks and rot the carcass. Grit and dirt will soon work between rubber and tread, ruining the casing beyond repair.

SKIDDING. AND IMPROPERLY ADJUSTED BRAKES.

Brakes not properly adjusted are the cause of many casings wearing out prematurely.

One brake is sometimes tighter than the other, placing most of the strain on one tire.

This has the same effect on the casing as skidding. It soon grinds the rubber off the tread.

Have your brakes adjusted if your tire shows the tread ground down in spots.

THE CHANGING OF TIRES.

See that your jack is set firmly and is perpendicular. Do not place it against the truss rods,

but under the axle or under the spring bolts, where it cannot damage the machine.

After removing dust cap, remove valve plunger to hasten the deflation of the tube. Don't leave the dust cap, valve cap and plunger lying on the ground, but put them in your pocket or some place where they will be handy when you want them. Always have a few new valve plungers with you, as many a slow leak originates in a bad plunger.

A Three-in-One tool is a most valuable accessory. While you can remove the valve plunger by inverting the valve cap, the tool is handier and also enables you to remedy battered threads both inside and outside the valve. After deflating, turn the wheel until the valve is down, and push the valve stem into the case. Pull the tire toward you, so as to loosen the back bead, beginning at the top. The front bead will slip off readily enough, but the back one will sometimes stick. In that event reach into the case and pull the valve stem out. You will then have no trouble.

ON PROPER INFLATION.

There is no one thing more important in the care of tires than to keep them inflated properly. A good rule is to allow the tires to show no depression under the weight of the car when standing on a level floor. A daily test of the air pressure is necessary if the bad results of under-inflation are to be avoided.

PUNCTURES.

If a tire leaks it may not always be from a puncture. Test your valve first. This is easily done by moistening the valve cap washer before screwing down. If there is a leak small bubbles of air will be seen issuing from around the edges of the cap.

PINCHED TUBES.

Ninety per cent of tube troubles are due to pinching, from improper application of the tires to the rim. Either a flap gets misplaced, a tire tool gets jammed against the tube or the beads of the case catch it at some place where it is creased. Practically all instances of a tube letting go inside the case, without outside evidences of injury, are due to this cause, or to a bruise break in the fabric pinching the tube.

When a tube is put in a case it should be lightly inflated and the hand slipped around inside the case to feel that there are no wrinkles. The flap, if any, should be put in position in the same way. After the case is on and before final inflation, the bead should be raised all around with a tire tool to allow the tube to escape into place if the beads are pinching it anywhere.

Many tire experts agree that more than half of the number of tire troubles are due directly or indirectly to underinflation. As it is, in the case of the pneumatic tire, not the rubber but the air which carries, suspends and cushions the weight of the vehicle—everything, of course, depends on having as much air as possible in the tire tube, without approaching the breaking point of the rubber at the weakest place of the tube. Every molecule of air which can be safely held in place in the tube helps to do the work for which the tire is employed. Incidentally, it keeps tube and casing in the most desirable form, for which they are designed; and holding them rigidly, offers stones, nails and other road sundries such resistance as is needed to make the impact harmless.

WATER INJURIOUS TO TIRES.

When water works its way beneath the tread and breaker strip and into the carcass of a tire premature deterioration is certain to follow.

When a tire is completed it is free from moisture on the inside and it remains so as long as the tread is in condition to perform its full duties. However, small cuts, caused by sharp objects in the roadway, are very apt to appear, even in a new tire, and through these openings water eventually finds its way to the tire carcass. In time this produces separation of the individual plies of fabric of which the carcass is made up, and the tire rapidly goes to pieces. Breaks in the tread also admit sand and dirt, which cause fabric separation.

When a motorist discovers one or more small cuts in the tread of a tire he should close them at once. There are several special preparations for this purpose which can be easily applied after the cut has been thoroughly washed out. The expense amounts to practically nothing and the saving is bound to be great.

TIRE POINTERS.

Air costs nothing; tires are expensive.

More tires give out from insufficient inflation than anything else. Remember that it is the air in the tube that carries the load and cushions the road.

Avoid sudden application of the brake.

If one side of a tire shows more wear than another, turn it around.

Running on a tire flat, even a short distance, is sure to be costly.

Better run on the rim, very slowly and carefully, if imperatively necessary, and the distance is very short, than on a flat tire.

Keep grease and oil away from your tires and tubes always. They destroy rubber.

THE CAUSE OF A BLOW-OUT.

No doubt every motorist has had the experience of the so-called "blow-out." This experi-

ence affects all in the same way. It is nothing but an exasperation, and although a blow-out can often be repaired, the motorist cannot help preferring never to have had it in the first place.

Today the importance of the automobile tire industry has fostered an improvement of the tire as now manufactured, to the point that the motorist who cares can, by a few simple precautions, protect himself from the blow-out bugaboo.

A blow-out is due to one of a few simple causes, which if given the necessary attention can be easily avoided. To prevent the blow-out we seek the cause and eliminate it. Accordingly, we will show and explain briefly the different causes of blow-outs.

The amount of air in a tire is just as important as the tire that contains it. Improper inflation renders a tire susceptible to blow-outs, just as proper inflation prevents this annoyance. This is the reason:

The body of the tire is of fabric; several plies are used and the mass, after being thoroughly impregnated with rubber is vulcanized into an integral whole—the tire. Over the body is a layer of rubber—the tread.

What happens when a round stone, a brick, a car track, or any blunt object is encountered? If the tire is improperly inflated the internal air pressure not offering sufficient resistance, the object will sink into the tire, forcing it inward at this one place. The tread comes into actual contact, but its elasticity allows it to adapt its shape so that it usually suffers no injury, unless the object be sharp and cuts it. But the effect on the fabric is more serious. It isn't elastic; it can't stretch; consequently, if the object sinks in far enough to produce enough strain, it must break.

Naturally, that ply of fabric receiving the greatest strain is the inside one, for it undergoes the

greatest distortion, and for this reason it is the first to break. Seldom, indeed, is any shock violent enough to break every ply of fabric and cause an immediate blow-out. Most always it is only the inside ply that is fractured at the time. As this isn't apparent, the tire usually continues to give service, but the broken edges of the inside fabric chafe the other plies. The natural bending of the tire finally breaks the remaining plies, and then the tube forces its way through, resulting in a blow-out.

This is the first warning the motorist receives that something is wrong. He didn't know the fabric was broken some time before. He sees nothing but the immediate conditions, and doesn't realize that his misfortune is something he could have prevented if he had only known how.

The reason the inside ply of fabric broke in the first place, was the result of improper air pressure. This permitted the object on the road surface to sink in and stretch the fabric at one place to the breaking point. Had the pressure been of the proper amount it would not have been possible for the object to have made such an impression. The internal air pressure would have offered the proper resistance, and the shock instead of being localized would have been distributed all over the tire, and so absorbed without injury. .

Hence the remedy: Use the air gauge, and carry the proper pressure.

Again, the tread has received a cut. Various foreign substances from the road surface are forced through the cut by the motion of the tire. As a result, these impurities have a tendency to spread, separating the tread and fabric. This opening of the tread lays the fabric bare to road wear and the action of sand and moisture. The latter rapidly rots the fabric, weakening it until

the pressure can no longer be sustained, and then the same aforesaid fatality occurs.

For this the remedy is repair gum. Cuts repaired in time will grow no worse, and so these consequences are avoided.

In conclusion, there are two important causes of blow-outs—under inflation, which results in the breaking of the plies of fabric, and neglected tread cuts. Avoiding these by means of a pressure gauge and a can of repair gum, the motorist will be able to avoid the trouble to which they lead—the blow-out.

Cleaning the Car

WASHING.

WHEN a car is new, wash it with cold water, as it will help to set the varnish. Luke-warm or cold water are ordinarily used in washing the car, but never use hot water, it will ruin the painting.

To remove grease or oil on fenders and wheels, some brand of automobile soap (commonly known as soft soap), dissolved in water, can be used; however, *do not* use on body, as it affects the gloss of the varnish. When purchasing a soap of this kind, you can be somewhat safe by inquiring what it is made from. A soft soap made of pure vegetable oils, chemically neutral and containing no free alkali, or any other acid or grit to bite into fine finishes, is recommended.

Do not wash the hood when it is warm, as this will cause it to lose its lustre.

Do not rub body with sponge unless necessary; it always holds sand or grit. Wash by rinsing off as much as possible.

Do not play a sharp stream of water onto car while washing; it will drive small particles of sand, miniature stones, etc., into the paint.

It requires considerable skill to wash a car properly without injuring the finish; but the improved appearance makes it well worth the trouble. Automobiles are subjected to harder service than any other vehicle. They are exposed to all kinds of road and weather, spattered with grease from oiled roads, scratched by flying sand and gravel: they are left standing in sun, wind and snow, and as a rule no very great care is used in cleaning them afterwards.

The manufacturers spend much time and money in giving automobiles a fine finish with a high lustre. This finish can be quickly spoiled by lack of care, or may be preserved by using proper precautions.

Light dust may be blown off or removed with a feather duster. When necessary to use water, let it run slowly from a hose with a sprinkling nozzle or no nozzle at all. If a small nozzle is used which adds force to the stream, it will drive the sand into the finish and soon remove its gloss. Dried mud should be removed as soon as possible, as it injures the finish. It should never be wiped off dry. Soak it with water applied with a sponge or a gentle stream from a hose; after it is softened, wash it away carefully.

Soap is not necessary for removing dust or mud. It must be used, however, when the surface is stained with road oil or from some other causes. Never apply soap directly to the finish. It is much better to dissolve it in water and make suds of suitable strength. Any soap, no matter how mild or neutral, will injure varnish if left standing on it. Dissolving soap in water is much safer, and is also more economical, because it does not waste the soap.

Suds made as above will remove all greasy stains.

When through washing, dry carefully with a chamois.

CLEANING OF NICKEL-PLATED PARTS.

Lamp black or regular silver cleaner paste are most frequently used to clean nickel-plated parts. Use a soft flannel or chamois to rub with.

Lamp reflectors can be cleaned with Putz Pomade, applied and polished with soft, clean chamois.

Symptoms of Common Troubles

WHEN THE MOTOR STOPS:

1. Look at gasoline supply.
2. Wires disconnected.
3. Not enough oil in motor crank case (will be noticed by motor knocking, and finally stopping).
4. If the motor cannot be cranked, look for transmission to be engaged; bearing seized due through lack of oil.

WHEN THE MOTOR MISSES:

1. Defective spark plug.
2. Insulation broken on wire; wire disconnected.
3. If the motor spits back through carburetor, look for dirt in same. Gasoline supply cut off from water or dirt in gasoline line. Water in the gasoline pipe will sometimes freeze and cut off entire flow.
4. Compression weak in any one cylinder valve; push rod or valve sticking. Dirt under valve. Valves not seating properly, may need regrinding.
5. When the motor runs and quits, then runs again, it is probably due to something like water or dirt in gasoline line.
6. A missing cylinder can be located by opening priming cocks on top of cylinders one at a time. If the trouble is not in the spark plug, attention should be given the valve to note if it is seating properly as well as opening and closing at proper time. The loss of compression will be detected by turning motor slowly by hand. Each

cylinder may be tested individually for compression by closing all priming cocks excepting one. After having tried one particular cylinder, open the priming cock in same and turn off another in some other cylinder. In this way you will have discovered the weakest cylinder.

7. Worn or blown-out gaskets of intake manifold joints will cause missing.

POWER LOSS:

Motor will run good on level travel, but loses power on hill or under heavy load.

1. Valves not seating properly, causing loss of compression.

2. Spark too far retarded. Ignition late.

3. Carburetor flooding causing too rich a mixture.

4. Motor running hot through lack of oil or water.

5. Not enough gasoline, probably due to stoppage in pipe. If the motor spits back through carburetor upon sudden opening of the throttle, this indicates there is a lack of gasoline.

6. Tire down.

7. Weak mixture in carburetor.

8. Examine brakes. Feel to see if they are hot, due probably to dragging. Push car along the floor or road by hand and notice if it rolls easily.

CANNOT START MOTOR:

1. Examine gasoline supply.

2. Be sure switch is on.

3. Weak mixture.

Don't try to change adjustments without knowing why you are making them, as it will only cause more serious trouble.

Don't get excited. Many an experienced autoist has cranked his car a few hundred revolutions and finally discovered it wouldn't start because the switch was off.

WHEN THE MOTOR KNOCKS:

1. A light knock running at high speed invariably indicates a loose connecting rod bearing.

2. A heavy, dull pounding running at slow speed with the motor under load purposes to be a loose crankshaft bearing.

3. A motor laboring on hill or pull, due to the motor running too slow on direct drive, will cause pounding or knocking.

4. Carbon knock; excessive amount of carbon gathered in cylinders.

5. A light clicking or tapping sound is often contributed to too much play or space between valve push rod and valve stem.

6. A spark knock is often caused by operator carelessly advancing same too far.

OVERHEATING OF THE MOTOR:

1. Water supply too low.

2. Fan belt slipping.

3. Gasoline mixture too rich.

4. Cylinders heavily carbonized.

5. Circulation stopped, due probably to pump not working or some stopped up water pipe.

6. Ignition too late.

7. Not enough oil in motor.

What is Horsepower?

WHAT is horse-power? This question, while well understood by engineers in general, is a hard problem for the beginner to grasp. Horse-power provides a never-failing source of discussion for him. No other term in his vocabulary is so misunderstood, or has so many interpretations, and at the same time it is a subject of vital importance to him, for the reason that it affects his comfort, his pride or his bank account.

The purpose of this article will be to enlighten him on this subject, and at the same time show how the horse-power of an automobile engine can be approximated very closely by the A. L. A. M. formula, giving an example as well as a table. The table comprises cylinder diameters of $2\frac{1}{4}$ to 6 and engines having 1, 2, 4, 6 or 8 and 12 cylinders. No mathematical data is used, to avoid complications.

The definition of the word "horse-power" as applied to a motor car engine is not understood by the average automobile owner or driver. There are many laymen who think that by horse-power is meant the average load which a horse can pull in continued service. This is not true, however, as the pulling power of horses varies and no definite point could be reached in this way. It is evident that a large horse is capable of pulling a greater load in continued service than a smaller animal.

The term "horse-power" was first used by James Watt, after numerous tests of the load which the average horse could pull in continued service and a constant derived therefrom, which will be discussed later.

Horse-power as a technical term has a very definite meaning. It is defined as the rate of doing work. Work, in turn, is the product of a force and the distance it moves. Thus horse-power is force times distance divided by time. It is expressed in units implying these three quantities: pounds, per foot, per minute. One horse-power is equivalent to 33,000 foot pounds per minute, that is, a power which can lift 33,000 pounds one foot in one minute, or 1,000 pounds 33 feet in one minute, or 1 pound 33,000 feet in one minute, or 1 pound one foot in $1/550$ second.

In a motor car engine power is developed by the burning and consequent expansion of the gasoline mixture in the combustion chamber. The expansion results in a force exerted on the piston head, the travel of the piston on its stroke gives the distance, and the number of revolutions per minute of the crankshaft adds the time factor. Given the pressure in pounds per square inch of the cylinder, the stroke in feet or inches, and the number of revolutions per minute, the horse-power developed in a gasoline motor can easily be computed. Although the last two quantities are easy enough to obtain, the first, unfortunately, cannot be had without the use of delicate and costly instruments.

To determine the power actually developed by a motor, numerous methods can be used, but all depend upon the absorption and incidental measurement of the power, as by a friction brake, electric generator, a water pump or fan. As the earliest and best known of these the friction or prony brake method may be described. Like all others, it depends upon the definition of force times distance divided by time. The application is generally quite familiar. A brake band or shoe is applied to the fly-wheel and prevented from rotating with the fly-wheel by weights at-

tached to the end of the lever arm attached to the brake band. The weight or the length of the lever arm is adjusted until the weight is in equilibrium, tending neither to rotate with the fly-wheel or to drop under the force of gravity. The weight then gives the force, the length of the arm the distance, and the number of revolutions the time factor necessary for calculating the horse-power.

In many automobile plants where motors are made in large quantities, the run in test is regarded as a necessity and it is a simple expedient to attach a fan to the fly-wheel in place of the clutch, and, if the fan is properly devised, it will limit the speed of the motor to that which should obtain in actual service, when the motor is doing its accustomed work. The fan requires no attention; it offers a constant resistance, so long as the speed of the motor is maintained constant, and if the speed changes do creep in they will indicate that some adjustment is necessary to either mixture or ignition system, but there will be no damage done, even if the adjustments are not made. This form of dynamometer is economical; it takes up almost no added space, and it is, in first cost, at the bottom of the list. In some instances this fan dynamometer has been fitted with a tachometer, by means of which the power delivered may be noted by ascertaining the speed and comparing it with a chart of power for speed as determined by previous calibration.

In large automobile factories the balanced electric system seems to have considerable advantage. There may be a number of sets of these machines, and all that is required to satisfy conditions is to have the machines in pairs. One machine (of each pair) is driven by an engine as a dynamo, which furnishes current to the other, which as a motor drives the second engine

which is getting its "run in" test. The dynamo loads the engine which furnishes the power, which is electrically transmitted to drive the second engine, which is being run in during this period of time.

There is still another possibility. If the engine to test is connected to a centrifugal pump and the pump in turn by piping to a reservoir, the power required to pump the water to the reservoir may be adjusted to equal the ability of the motor to be tested and the work done in the process turned to good account.

It should be understood that the motor testing question has other angles besides the one which

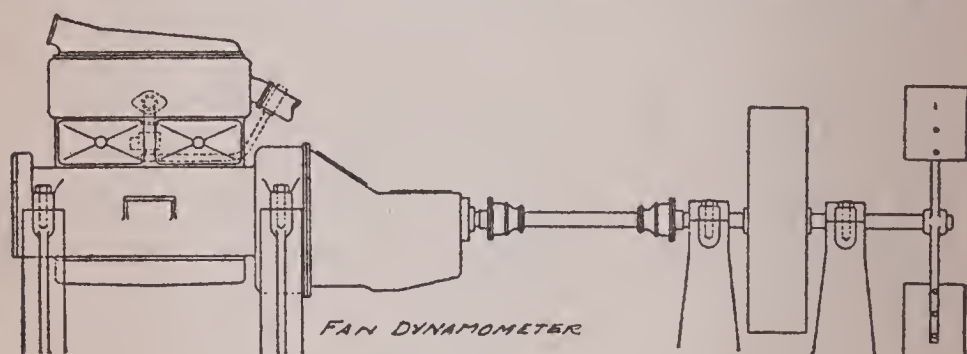


Fig. 34.

is being considered here; investigations of the internal conditions are also taken into account.

Obtaining the cylinder pressure in pounds per square inch, that is, the force exerted upon the piston by the expansion of the gas, unfortunately cannot be obtained without the use of delicate and costly instruments, as mentioned above. For this reason a formula was adopted by the Society of Automotive Engineers, which is termed the S. A. E. formula, and which was intended to approximate the horse-power of automobile engines very closely. This formula received such a favorable reception by both manufacturer and user that its continued use has been assured. Before its appearance there had been a long-felt need of some connecting

link between the size and probable capacity of the various motors. Most objections to this formula are based upon the idea that it is to determine once and for all the power which a given motor is capable of developing. This is not true, as the horse-power of a gasoline engine cannot be computed exactly from its dimensions by any formula whatsoever, no matter how intricate and learned in appearance.

The principal feature considered in this formula is simplicity, and this is an unquestionable advantage. It would be impossible to simplify it any further and still obtain the least approach to the horse-power rating. There is, however, one short cut, which might not appear to the layman. For instance, the formula reads: $H. P. = \frac{D^2 N}{2.5}$, which in reality is the same and equal to $H. P. = .4 D^2 N$, as will be explained later.

In the formula—

D = Diameter of cylinder in inches.

N = Number of cylinders.

2.5 is a constant based upon a mean effective pressure of 70 pounds per square in. and a piston speed of 1,000 ft. per min.

D^2 is read as the diameter squared, and to square any number is to multiply it by itself; that is to say, the square of 2 is equal to $2 \times 2 = 4$, or $4 \times 4 = 16$, or $16 \times 16 = 256$. Likewise any number multiplied by itself will give the square of that number.

In using the formula, remembering that the power of a motor is in proportion to the square of the cylinder diameter, the formula may be written as follows:

Horse-power = Diameter of cylinder in inches squared, multiplied by the number of cylinders contained on the engine and divided by the con-

stant 2.5; or to transpose the formula, Horse-power = .4 times the diameter of cylinder in inches squared, multiplied by the number of cylinders.

Citing, for example, a four-cylinder motor with a cylinder diameter of four inches, and proceed to calculate the horse-power of the engine.

$$\text{H. P.} = \frac{4 \times 4 \times 4}{2.5} = 25.6 \text{ or } .4 \times 4 \times 4 \times 4 = 25.6$$

For six cylinders, four-inch cylinder diameter—

$$\text{H. P.} = \frac{4 \times 4 \times 6}{2.5} = 38.4 \text{ or } .4 \times 4 \times 4 \times 6 = 38.4$$

And again for an eight-cylinder engine—

$$\text{H. P.} = \frac{4 \times 4 \times 8}{2.5} = 51.2 \text{ or } .4 \times 4 \times 4 \times 8 = 51.2$$

And for twelve-cylinders—

$$\frac{4 \times 4 \times 12}{2.5} = 76.8 \text{ or } .4 \times 4 \times 4 \times 12 = 76.8$$

Using precisely the same method the horse-power of any motor (according to this empirical formula) may be approximated. Still further convenience may be had by the use of a table such as the accompanying one, especially for fractional values of the bore. This table is in the main self-explanatory, but a few features may be pointed out. The values are given so close together that intermediate values may be found by interpolation. Thus $4\frac{1}{16}$ inch is half-way between 4 and $4\frac{1}{8}$, and consequently the power of a $4\frac{1}{16}$ -inch four-cylinder motor is between that of a 4 and $4\frac{1}{8}$ -inch motor.

For example, we will take these three cylinder diameters in order to show the interpolation is carried out. We must first find the difference between the 4 and $4\frac{1}{8}$ -inch motors. Referring to the table, a $4\frac{1}{8}$ -inch four-cylinder motor is rated at 27.20 H. P., while the 4-inch is rated at 25.60 H. P. Now, subtracting this from the former, we get 1.60 H. P. Half of this sum added to the power of the 4-inch motor will give us the power of $4\frac{1}{16}$ -inch motor, thus:

S.A.E. HORSE-POWER TABLE.						
BORE	CYLINDERS					
	1	2	4	6	8	12
2¼	2.02	4.03	8.10	12.15	16.20	24.30
2½	2.25	4.51	9.02	13.52	18.05	27.07
2½	2.50	5.00	10.00	15.00	20.00	30.00
2¾	2.83	5.66	11.23	16.85	22.41	33.64
2¾	3.02	6.04	12.08	18.13	24.16	36.24
2¾	3.34	6.68	13.37	20.00	26.74	40.11
3.0	3.60	7.20	14.40	21.60	28.80	43.20
3½	3.91	7.82	15.64	23.50	31.28	46.92
3½	4.23	8.46	16.92	25.39	33.84	50.81
3½	4.57	9.10	18.21	27.30	36.42	54.63
3½	4.90	9.80	19.61	29.45	39.22	58.83
3¾	5.27	10.54	21.08	31.57	42.16	63.24
3¾	5.62	11.25	22.50	33.75	45.00	67.50
3¾	6.05	12.11	24.22	36.32	48.44	72.66
4.0	6.40	12.80	25.60	38.40	51.20	76.80
4¼	6.80	13.60	27.20	40.80	54.40	81.60
4¼	7.25	14.50	29.00	43.50	58.00	87.00
4½	7.66	15.32	30.65	46.00	61.30	91.95
4½	8.10	16.20	32.40	48.60	64.80	97.20
4½	8.57	17.14	34.28	51.41	68.56	102.84
4¾	9.03	18.07	36.15	54.20	72.30	108.45
4¾	9.56	19.12	38.25	57.21	76.50	114.75
5.0	10.00	20.00	40.00	60.00	80.00	120.00
5½	10.55	21.10	42.20	63.20	84.20	126.40
5½	11.05	22.10	44.20	66.40	88.40	132.60
5½	11.58	23.17	46.34	69.50	92.68	139.02
5½	12.12	24.24	48.48	72.72	96.96	145.44
5½	12.70	25.40	50.80	76.10	101.60	152.40
5¾	13.25	26.50	53.00	79.50	106.00	159.00
5¾	13.81	27.63	55.28	82.88	110.56	165.88
6.0	14.40	28.85	57.70	86.64	115.40	173.10

Fig. 35.

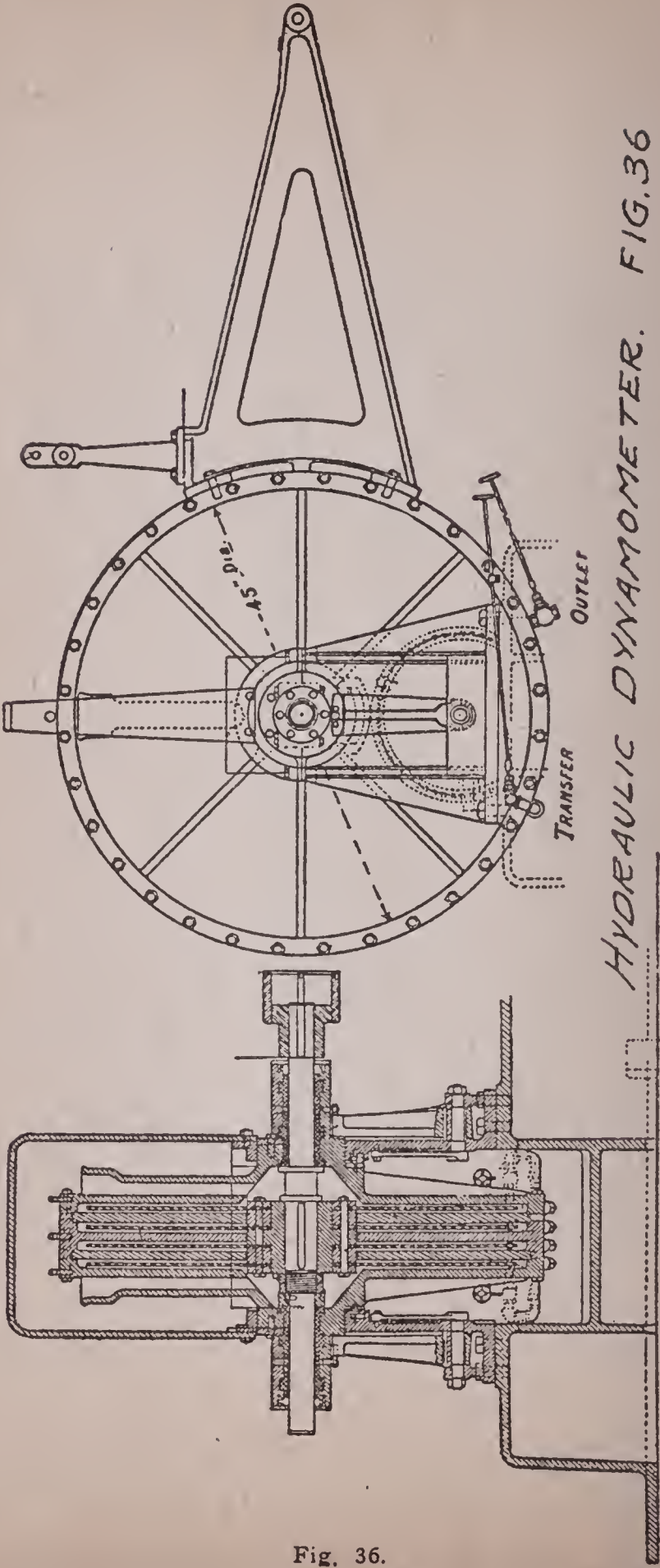


Fig. 36.

$1.60 \div 2 + 25.60 = 26.40$ H. P. In precisely the same manner any other size in between those listed can be found.

As horse-power by this formula is proportional to the square of the cylinder diameter, doubling this multiplies by four and halving it divides by four. Applying this to the table, the power of a two-inch cylinder will be one-fourth of the power of a four-inch cylinder, and the power of a seven-inch cylinder will be four times that of a $3\frac{1}{2}$ -inch or 19.60 H. P.

As a final criticism of the formula, and a warning against its too confident use, it will suffice to state that it tends to overrate small motors and underrate large motors. This really makes very little difference, for no one is interested in a close comparison of a three-inch and a six-inch motor, as he is of one more nearly the same size and within the variation of an inch or so in the diameter, the formula is very reasonably accurate. Empirical formula will avail up to a certain point and within certain explored limits. In a motor, for illustration, the formula will work very well, indeed, if the cylinder diameter is within the domain found to conform to the conditions which rendered the formula possible.

The Steering Gear

ONE of the essential features of a motor car is the method by which it is controlled, and the most essential element of control is the steering gear. The requirement of an automobile steering gear is radically different from those of other vehicles.

Horse-drawn vehicles are ordinarily steered by means of a fifth wheel attached to the forward unit of the vehicle gear which pivots on what is known as the king bolt; however, the divided axle is universally employed on all self-propelled vehicles. This was described in another chapter on "Front Axles," and this arrangement of pivoting the wheels is known as the Ackerman steering gear.

With a fifth wheel the leverage is obtained by a tongue or pair of shafts, while motor car front wheels are pivoted independently, as pivoting the front axle would involve serious complications, as in thrusting one or the other of the front wheels over the road at a rate of speed faster than the onward movement of the vehicle on a rough road would require considerable effort.

Technically, the Ackerman steering gear has been revised, and at present it is based upon the principle that if the vehicle is to turn a corner without lateral slip of any of the wheels, the steering linkage must be so arranged that axis of all wheels produced always intersect a common vertical line, this vertical line forming a momentary axis of rotation.

As the front wheels are pivoted independent of the front axle, which remains stationary, they

must be connected by a tie-rod through levers mounted on the knuckles or pivots, while a connection with the steering mechanism must also be made. This connection is termed the steering-arm connection and sometimes is referred to as the drag link.

THE STEERING MECHANISM.

Motor cars are steered by means of a hand-wheel mounted at the upper end of a steering column. This wheel is mounted on a spider, which is secured to a shaft passing through the column or outer tube, often termed the mast. At its lower end this shaft enters a housing, which houses a steering mechanism, to reduce the motion of the hand-wheel. This mechanism may consist of either a rack and pinion, bevel pinion and sector, worm and sector, or a screw and nut. The steering column is generally styled according to the type of steering mechanism. This mechanism must always consist of two members, one of which is attached to the steering shaft, while the other is attached to another shaft which carries the steering arm.

It is now general practice to make the steering mechanism back locking or irreversible, as the forces acting on the road wheels act as a disadvantage upon the operator's hands.

Steering mechanisms are made irreversible by so arranging them that they operate freely when turning the hand-wheel, but require a considerable force to turn the wheel through the reducing mechanism, as in striking obstacles on the road surface.

DRAG LINKS AND TIE-RODS.

Drag links and tie-rods are usually of the same proportions and the general practice is to provide the former with springs to absorb some of the shock which is transmitted to the steering

mechanism. There are various types of steering mechanisms and drag links employed at present, and in this chapter will be found illustrations and descriptions of all well-known types.

COMPONENT PARTS OF THE STEERING MECHANISM.

Fig. 37 gives a general idea of a complete steering arrangement of all passenger cars and represents conventional practice.

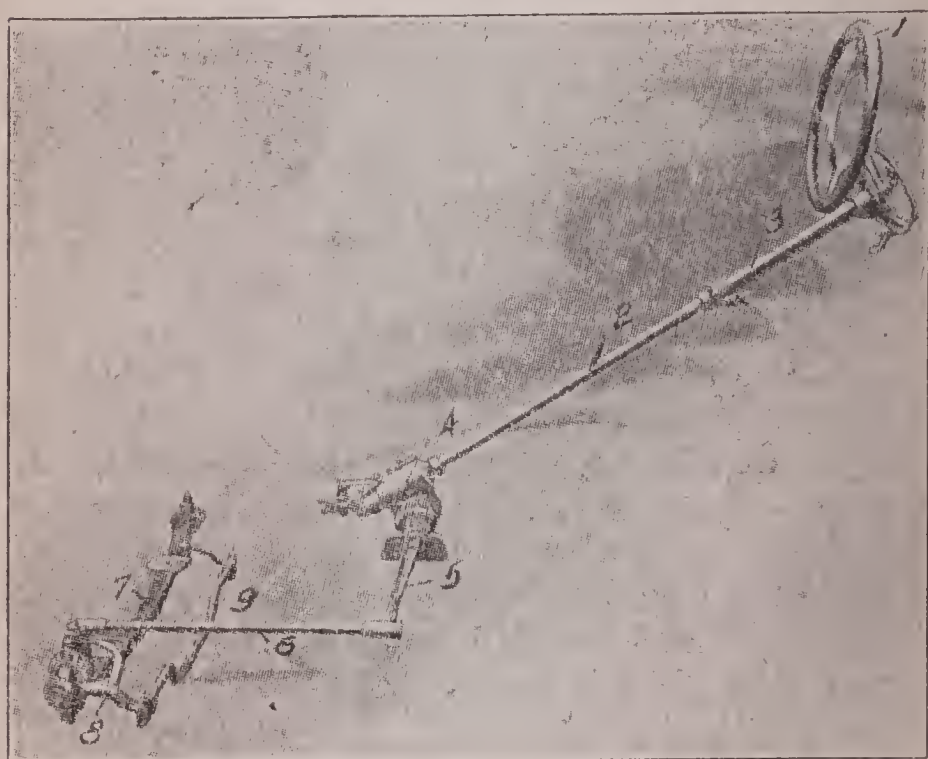


Fig. 37.—Component parts of the complete steering mechanism of a motor car.

In this illustration, 1 is the hand wheel; 2, the steering shaft; 3, the column mast; 4, the housing, which houses a worm and sector mechanism; 5, the steering arm; 6, the drag link; 7, the front axle; 8, the steering knuckle and lever; and, 9, the tie-rod. These parts go to make up a complete steering unit, and while various types of mechanisms may be used, they must be con-

nected as shown for fore and aft steering, while for cross-steering the drag link would be connected at some point on the tie rod, being retained parallel with the tie rod. The steering gear being so mounted as to give the ball arm a cross-wise instead of a fore and aft movement.

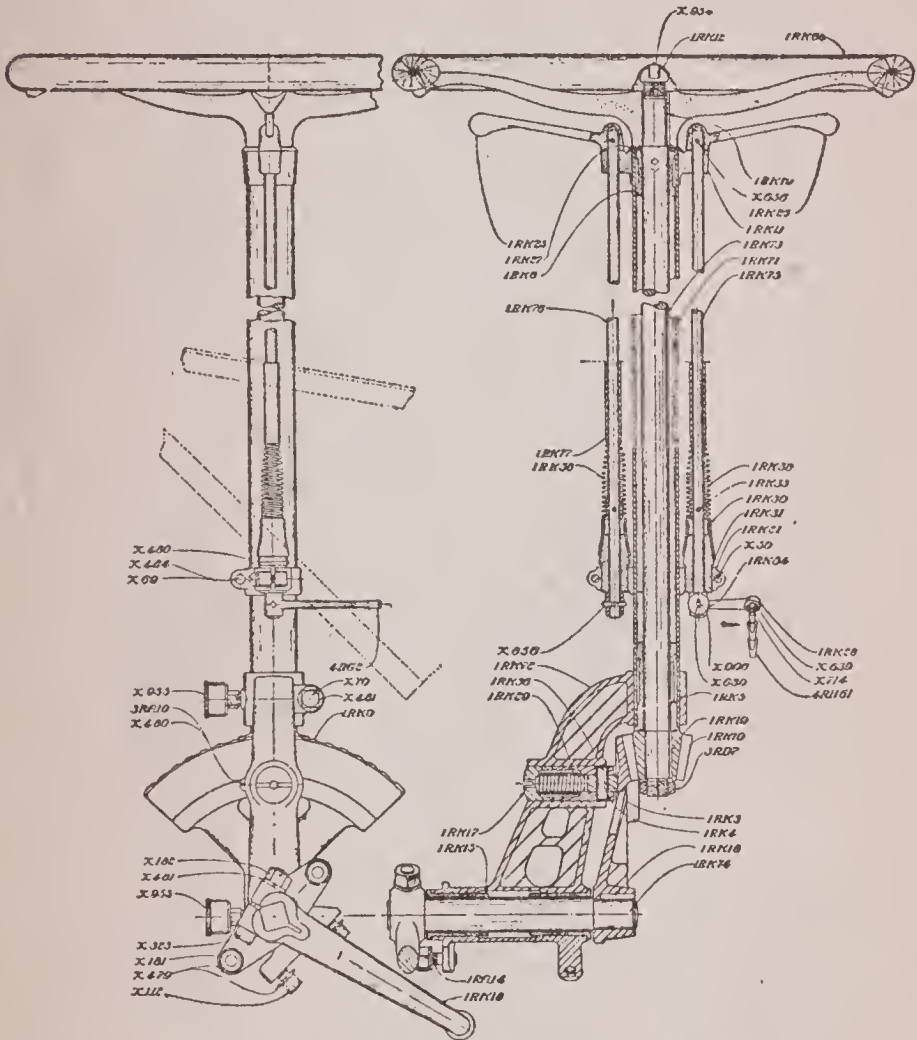


Fig. 38.—Bevel pinion and sector steering mechanism used on the Reo cars.

BEVEL PINION AND SECTOR TYPE.

Fig. 38 depicts this type of steering mechanism, which is used on the Reo cars. In this case the steering shaft is made solid, while the usual hand wheel and spider are secured to its upper end. The lower end of this shaft carries a bevel pinion which meshes with a sector having bevel

teeth and attached to a horizontal shaft carrying the steering arm. Steering motion is limited by leaving a portion of the sector without teeth, and the end thrust of this sector is taken by a steel roller, supported by a spring to maintain it in contact with the sector.

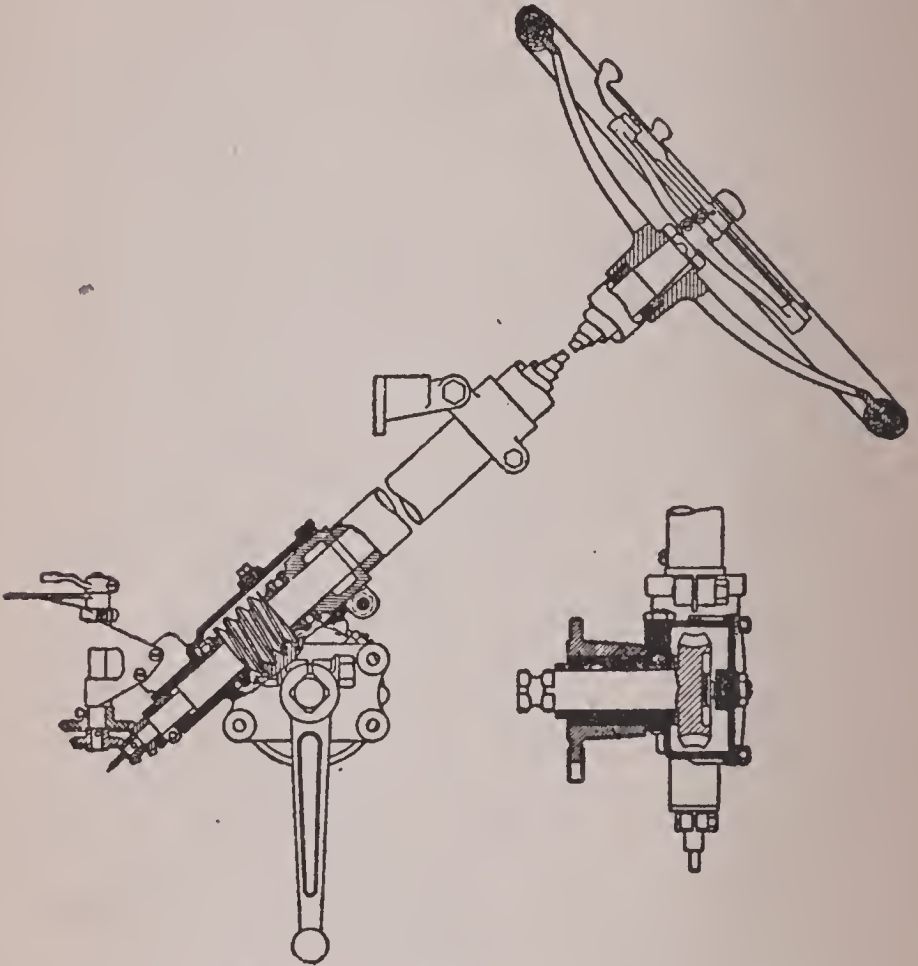


Fig. 39.—Worm and Wheel Type of Steering Gear.

The spark and throttle levers are mounted on opposite sides outside the column and are controlled by means of frictional members and springs located below the footboards. This type of mechanism has less need for a housing than other types and is also completely reversible.

THE WORM TYPE.

The worm type may either consist of a worm and sector or a worm and wheel. Fig. 4 illus-

trates the latter type, which is made by a prominent parts maker and used on a number of vehicles, and is representative of modern worm and wheel practice. Fig. 5 illustrates the

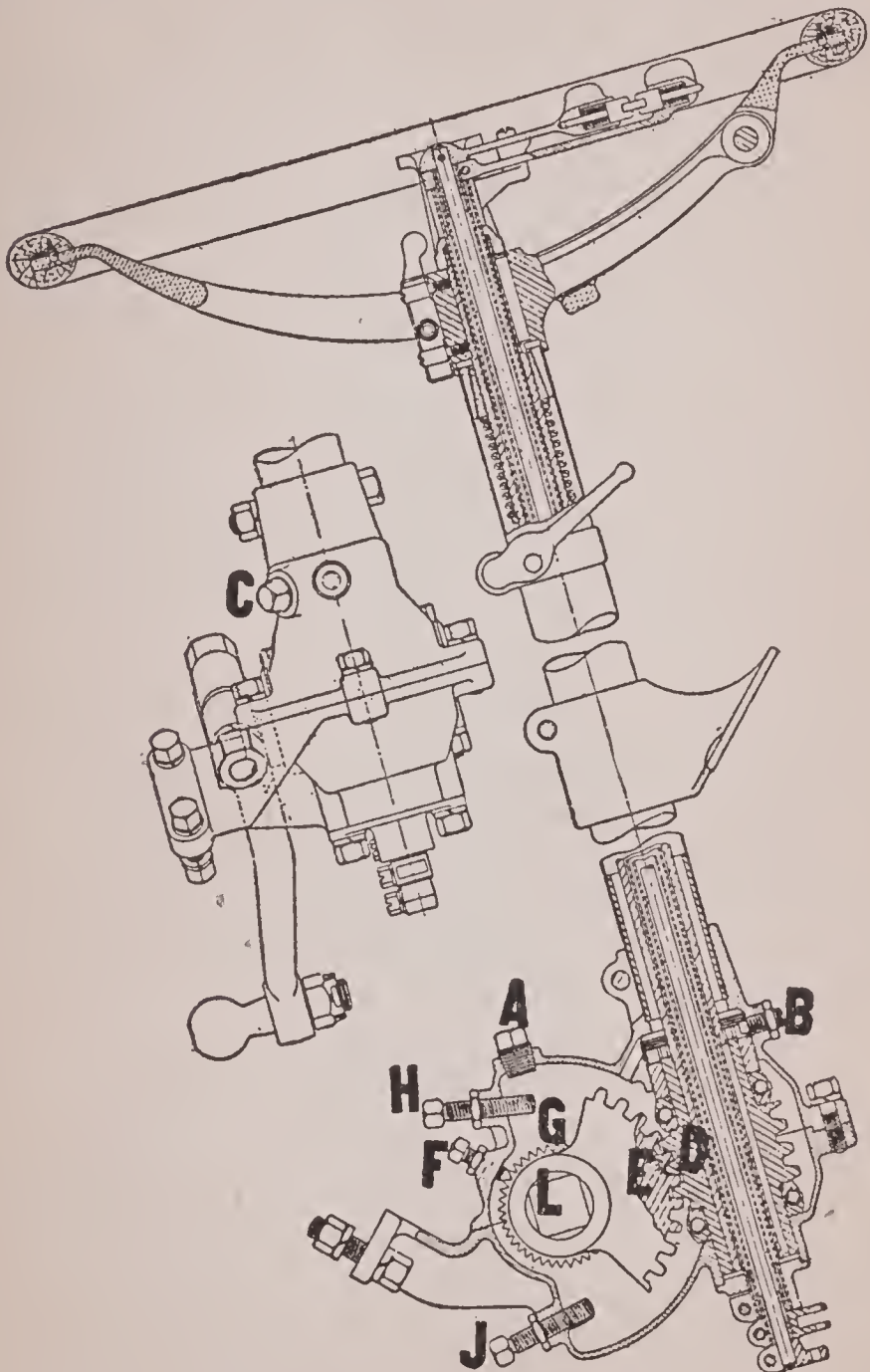


Fig. 40.—Worm and Sector Type of Steering Gear.

steering gear, which is of the worm and sector type. The gear is shown in section, and it will be noted that the ball arm which gives motion to the steering connection is mounted upon a

horizontal shaft, "L," which also carries the direction, depending upon the direction of rotation of the steering wheel. The ball arm, of course, moves in unison with the sector, since they are mounted upon the same shaft.

The steering shaft is hollow so that the carburetor and spark control shafts can pass through it. Ball thrust bearings are mounted on each end of the worm, which take the thrust in steering. Turning the steering wheel rotates the worm, which in turn moves the sector in each sector, "E," meshing with the worm, "D," mounted upon the steering shaft, "F" and "G," form an adjustment for wear, while "H" and "J" are adjustable stops for controlling the movement of the sector. "B" is a bearing lock, while "A" and "C" are removable plugs to permit the insertion of lubricant.

This gear is termed an irreversible type, as the ratio of the worm diameter to that of the sector gives a considerable leverage to turn the wheels, while the forces acting at the road wheel act as a mechanical force on the sector; however, as in this case the leverage is reversed, considerable force must be applied in order to turn the steering wheel.

THE SCREW AND NUT TYPES.

It is a well-known fact that a screw when rotated with a nut which is constrained from turning, but capable of sliding, can move the latter with a slight effort, but no ordinary force applied to push the nut is capable of turning the screw. The above arrangement constitutes a form of irreversible steering mechanism which is also quite popular. Designs differ in detail, principally in the manner of imparting motion to the horizontal shaft carrying the steering ball arm.

Fig. 41 depicts the Ross screw and nut steering mechanism, which is quite popular on commercial vehicles, as its design is based upon the principle that immense wearing surface is better than adjustment. The hollow steering shaft carries a steel screw at its lower end, mounted between two ball bearings to take its end thrust. This screw has a single thread of considerable length which is entirely enclosed by a carbon steel nut.

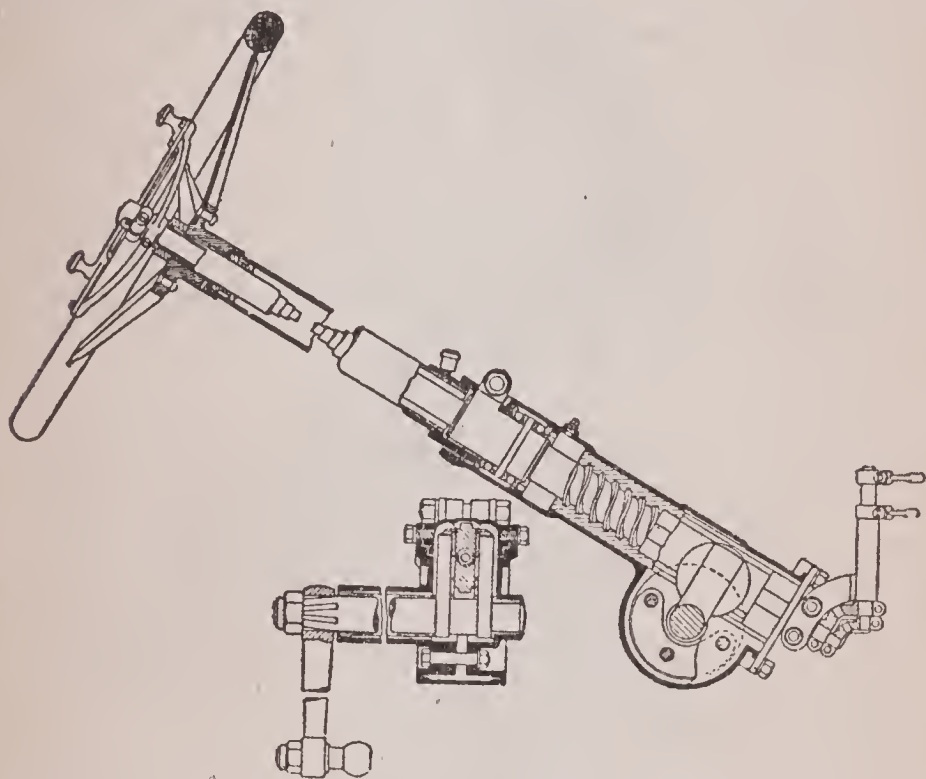


Fig. 41.—Ross Screw and Nut Steering Gear, with large wearing surfaces.

When the hand wheel is turned this nut is given lateral movement, as it is of square section and is thereby prevented from turning. On each side at the lower end of this nut cylindrical recesses are turned, and cylinders, which are free to rotate, are placed in these recesses. The cylinders have slots milled in them which receive a pair of arms projecting from the horizontal shaft carrying the steering ball arm.

The Jacox steering gear is also of the screw and nut type, but differs in several ways. This

gear has a substantial steel worm enclosed by a semi-steel nut which is split lengthwise into two halves. The worm is double-threaded both right and left-hand, so that in turning the hand wheel, one-half of the nut rises while the other falls. The horizontal shaft which carries the steering

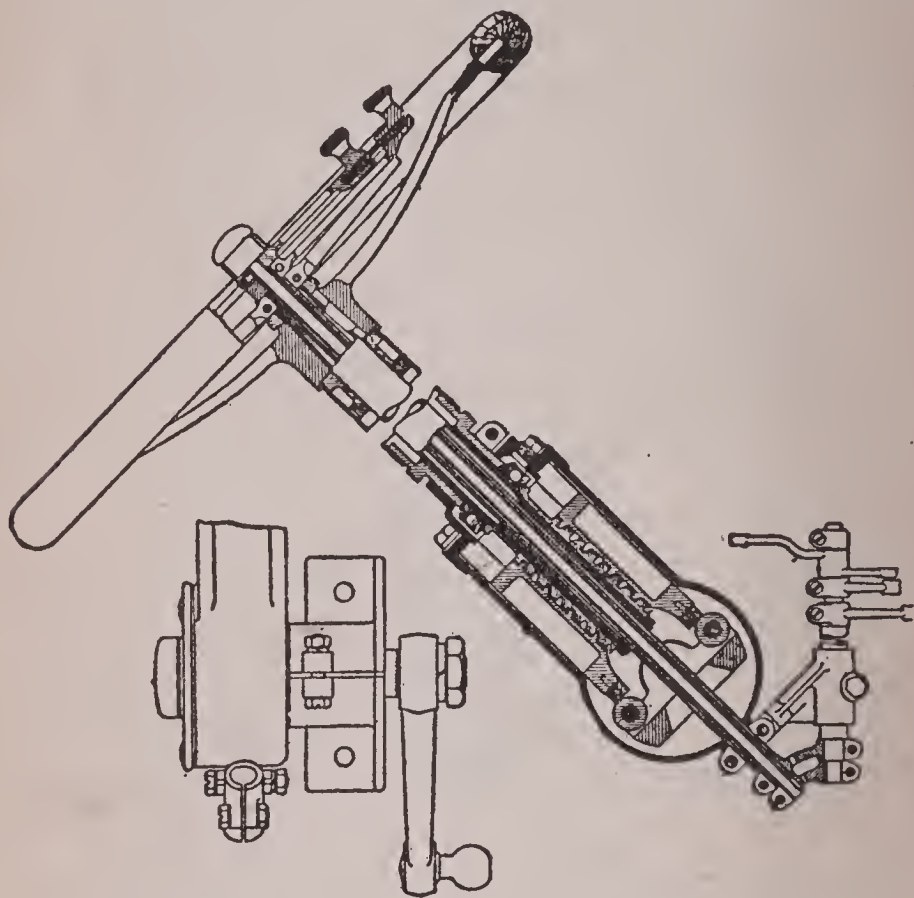


Fig. 42.—Jacox Screw and Nut Steering Gear.

ball arm has a rocking arm forged integral with it and the ends of the half nuts bear upon it. A ball thrust bearing is mounted at the upper end of these half nuts, which is so arranged that its adjustments take up all wear.

DRAG LINKS.

Fig. 43 illustrates a popular type of drag link or steering connection, which has springs at both ends to absorb shock, each end being provided

with an adjustment to take up spring tension and wear. These are generally made of tubular section for lightness and have electrically welded ends. Steering joints are usually enclosed in leather boots and packed with grease, which prevent dirt and grit from cutting the ball surface. The ball joints are universal in action and are

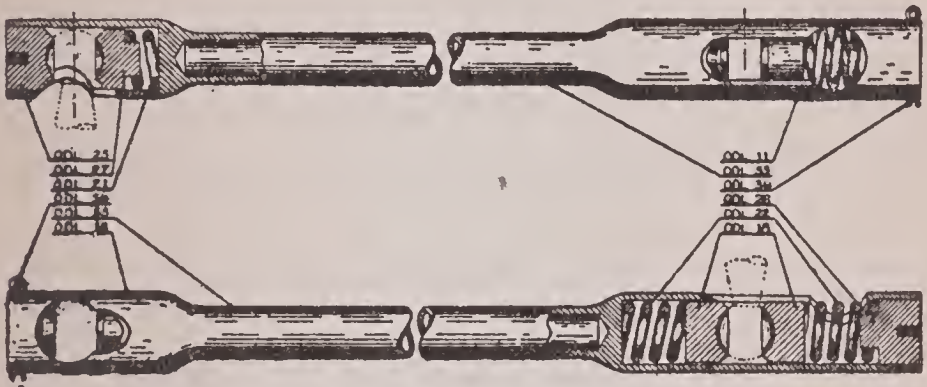


Fig. 43.—Conventional Type of Drag Link Steering Gear.

necessary at both ends of this member because the steering arm moves in a vertical plane and the steering knuckle on the axle moves in a horizontal plane; however, instead of these ball joints, fork joints are sometimes used. The latter are more simple and present larger wearing surfaces. However, they are more difficult to enclose and cannot be made adjustable.

The steering mechanism requires very little attention. Of course, all grease cups should be given a turn every day or two, depending upon the mileage, and they should be filled every week. Adjustments should be made promptly as conditions demand, and all parts should be examined thoroughly at least once during the season.

How to Oil an Automobile

PROPER ATTENTION TO DETAILS OF LUBRICATION
WILL SAVE TIME, REPAIRS AND REDUCE
THE UPKEEP OF MOTOR CARS.

MOTOR.

MANY different systems are employed to lubricate motor car engines, however, regardless of the method employed, they practically all require the same attention. It is considered good practice and generally recommended, that the motor oil be changed every 500 to 1000 miles and to always retain the proper level in the crankcase. Insufficient oil is dangerous and poor economy. Lack of lubrication will score the cylinders and ruin the bearings. Oil should be kept in a clean tank and always filtered before using. The measures or can used in replenishing the motor supply should always be thoroughly cleansed before using.

It pays in the long run to use the best quality of lubricants. Money saved by buying cheap oils will be lost in worn-out bearings or cylinders.

VALVES.

Valve levers, guides and other working surfaces of the valves operating mechanism, if not oiled direct from the lubricating system, should have a few drops of oil every few days, depending upon the amount of mileage.

MAGNETO.

A magneto should be oiled about every 1000 miles. Never use a heavy oil; the proper lubricant is a very light sewing machine oil. A few drops is all that is necessary. Be careful that lubricant does not reach any other part of the

instrument, except oil holes provided for this purpose.

ELECTRICAL UNITS.

The various parts of the electrical equipment will require a few drops of light machine oil every 500 to 1000 miles at certain points, depending upon the system employed, while others will require grease. The instruction book supplied with the car should be consulted as to the proper lubricant and procedure.

UNIVERSAL JOINTS.

If leather boots are used as universal joint dust covers they should be securely fastened in place again after lubricating. A heavy grease or mixture of graphite and heavy oil are used. These joints are usually reached by removing the floor boards.

TRANSMISSION.

There are a number of standard gear compounds on the market. Whatever is used, the combination should be of such consistency that it will follow the gears when they are in motion. It has been found that a steam engine cylinder oil, sold under the name of "600 W," is a good gear lubricant, especially if mixed with a little flake graphite.

Another good mixture frequently employed is two-thirds ordinary cup grease and one-third gas engine cylinder oil, mixed with a little graphite, which works very well. Fresh oil should be replenished about every 1,000 miles. When you have run 3,000 miles completely remove all old oil, and replenish with a fresh lubricant.

FRONT AXLE.

The front axle spindle bolts are usually supplied with grease cups and should be given a turn

every 250 miles. To thoroughly lubricate these bolts, jack up car and swing the wheels back and forth, working the grease where friction occurs in the bolts.

Like the spindle bolts, grease cups are generally provided on front axle distance rod and should receive occasional lubrication by turning down the grease cups. If the front wheels are equipped with roller bearings they should be cleaned and repacked with fresh grease about every 2,500 miles.

STEERING GEAR.

Grease cups are usually placed in the housing of steering gears for shaft, also sector and pinion shaft. These should be given a turn about every 500 miles. If oil cups are attached, oil same frequently. Steering gears usually have adjustments to take up back lash or looseness, and should be kept free from same.

BRAKE MECHANISM.

All brake rod clevis pins and connections should be oiled daily. In the event that brake rod pins are to be removed to make adjustments, you will find that you are well repaid by regular oiling, for these pins rust easily and are almost impossible to remove at times from neglect of oiling.

SPRINGS.

Springs are usually provided with grease cups at both ends and should be screwed down about every 25 miles. The spring shackles should not have any appreciable amount of side play between the ends of springs and their bearings in bracket or chassis of frame, since a small amount of end play will cause a disagreeable rattle in these shackles.

Springs when assembled are lubricated with a mixture of graphite, which is applied to the friction part of the leaves. When the springs become dry they will squeak badly, and this can be remedied by jacking up car and forcing graphite and oil between the leaves while they are partly open. In jacking up the car, place the jack underneath the frame, so as to let the axle hang free, which will spread the spring leaves somewhat.

CLUTCH, OIL PUMP, FAN BEARINGS, ETC.

In regard to oiling clutch, etc., instructions should be carefully followed concerning the particular make car you operate, and this information is usually supplied by the manufacturer of the car.

The Care of Axles

REAR AXLE APPENDIX.

THE following brief description of the character and functions of a differential is inserted for the benefit of those readers who may be unfamiliar with this exceedingly important part of the motor-car.

The differential consists of a set of bevel gears located at the center of the rear axle. Its purpose is to divide the power transmitted from the engine equally between the two wheels, and to do this in such a way that one wheel may revolve faster than the other when necessary, as in turning corners at high speed.

In a wagon the rear wheels are mounted on a dead axle and revolve independently of each other. There is, therefore, no need for a differential. In a power-driven vehicle the rear wheels must still revolve independently and yet each must receive one-half of the power transmitted through the rear axle.

To illustrate the principle in as simple a manner as possible we show in Fig. 44 an experimental apparatus in which A-A' are the two live axle

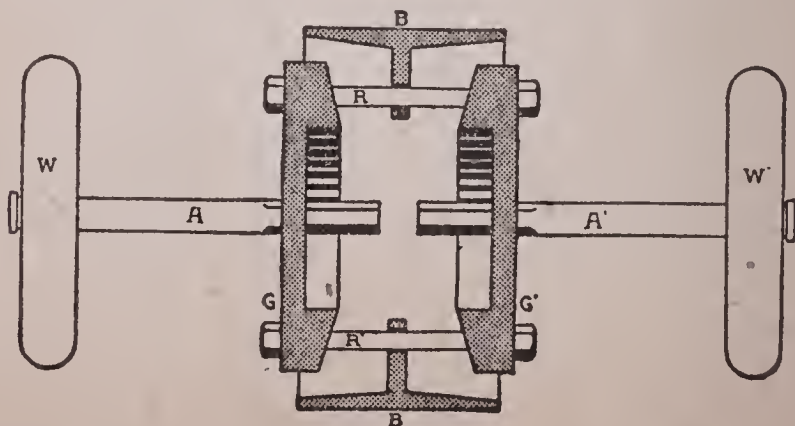


Fig. 44.

shafts to whose outer ends are fastened the wheels $W—W'$.

Mounted on the inner ends of the shafts $A—A'$ are the bevel gears $G—G'$. Surrounding these gears and concentric with them is a belt-driven pulley B .

It will be clear that if we connect the two gears solidly by the rods $R—R'$, which in turn are securely fastened in the web of the pulley B , movement of pulley B will cause both the gears $G—G'$ to revolve at the same speed in the same direction; and, since the wheels $W—W'$ are, like the gears $G—G'$, secured to the shafts $A—A'$, the wheels will also revolve at the same speed in the same direction.

Now, to allow the wheels $W—W'$, and, therefore, the gears $G—G'$, to revolve at different speeds, we remove the rods $R—R'$ binding the two gears together and substitute for these rods the pinions shown in Fig. 45. These pinions rotate freely on the web of pulley B and their teeth are in mesh with the teeth of the bevel gears $G—G'$.

It is clear that when the pulley B revolves, its motion is transmitted through the pinions to the gears $G—G'$ and on through the axles $A—A'$ to the wheels $W—W'$ just as it was transmitted in the apparatus shown in Fig. 1, but with this important difference—if wheel W is now prevented from revolving, the pinions will rotate on the web and thus allow the gear G' to revolve, carrying with it axle A' and wheel W' .

If gear G revolves slowly, gear G' can revolve rapidly, or vice versa, because the difference in their motion is compensated for by the rotations of pinions $P—P'$.

It will also be clear that in all cases, the pressure transmitted from the pulley B through the pinions $P—P'$ to the teeth of the gear G and the gear G' will be equal, because the distances be-

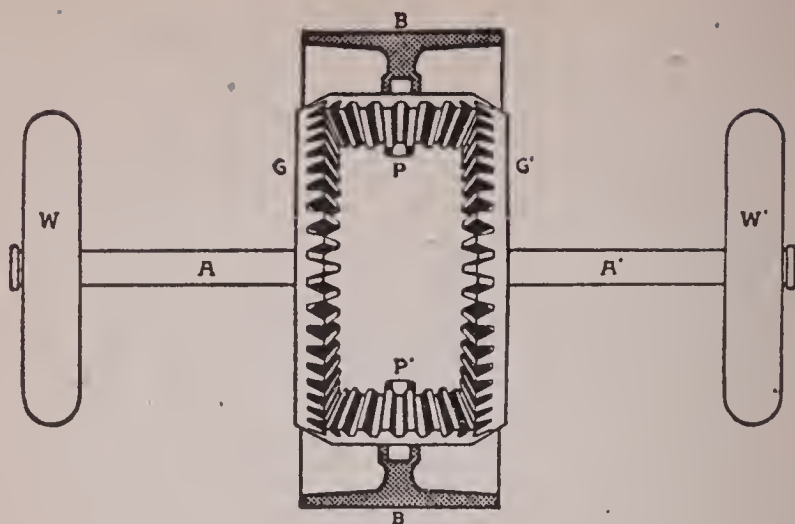


Fig. 45.

tween the centers of the pinions and the teeth of both gears are always equal.

In the simplest language possible, when gear *G* remains stationary, gear *G'* and the *pinions* roll around, as it were, on gear *G*, the teeth of the pinions pressing forward on the teeth of gears *G* and *G'* with equal pressure.

Referring now to Fig. 46 we see the differ-

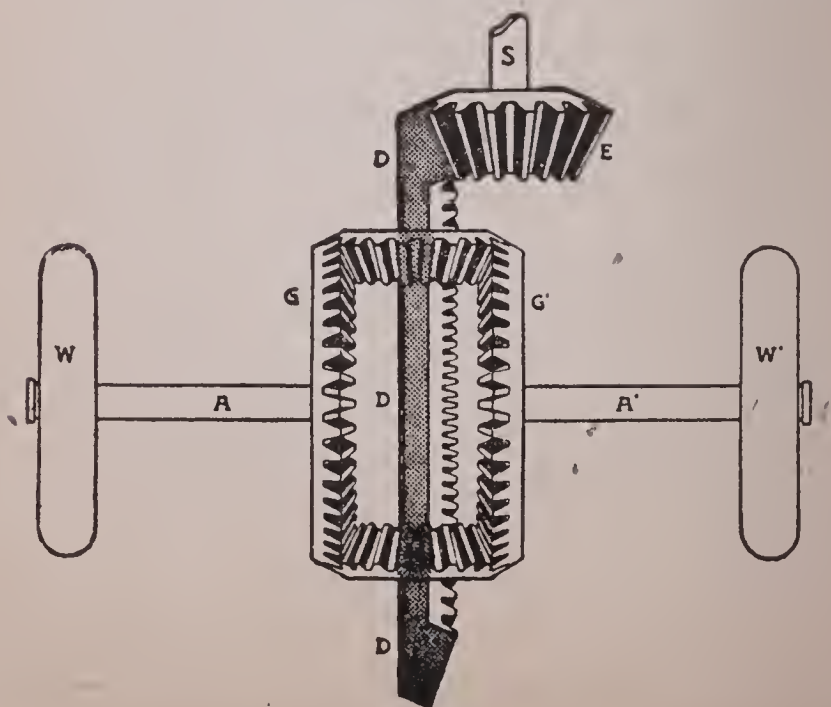


Fig. 46.

ential as actually used in the rear axle. In place of pulley B in Figs. 44 and 45, we have the driving gear D, and instead of two pinions there are now four, but the action is the same as that described for the apparatus in Fig. 45.

The driving gear D receives the power from a beveled gear known as the driving-pinion, the

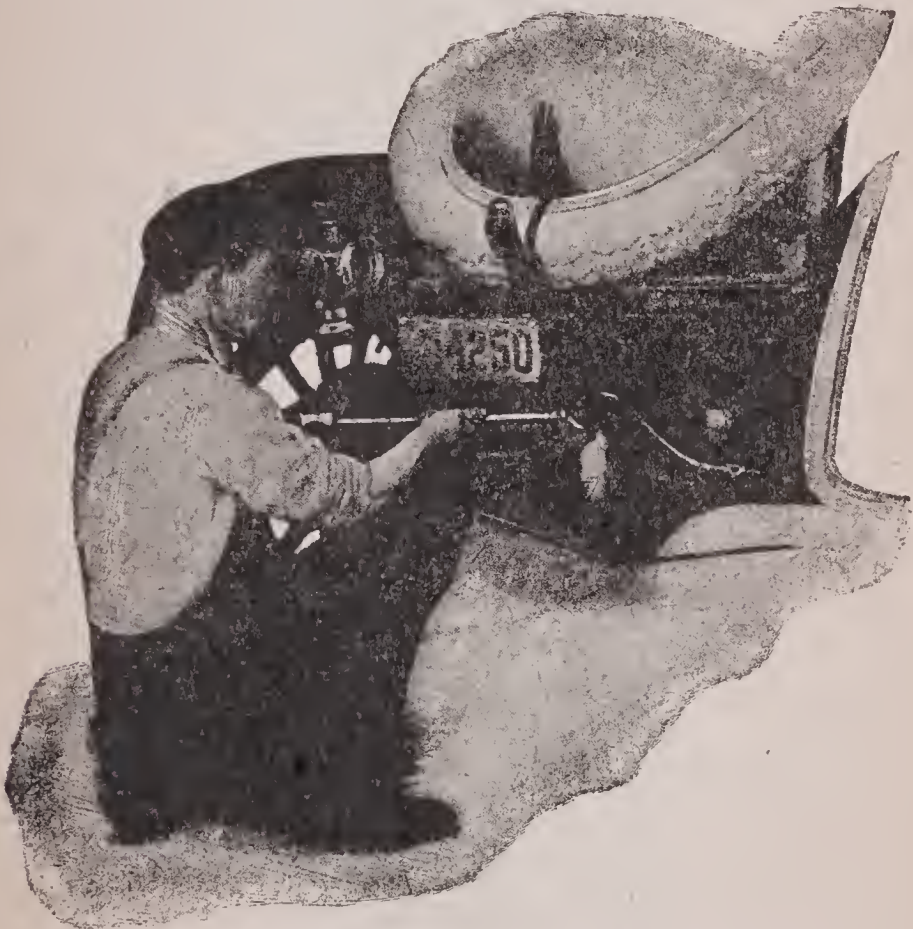
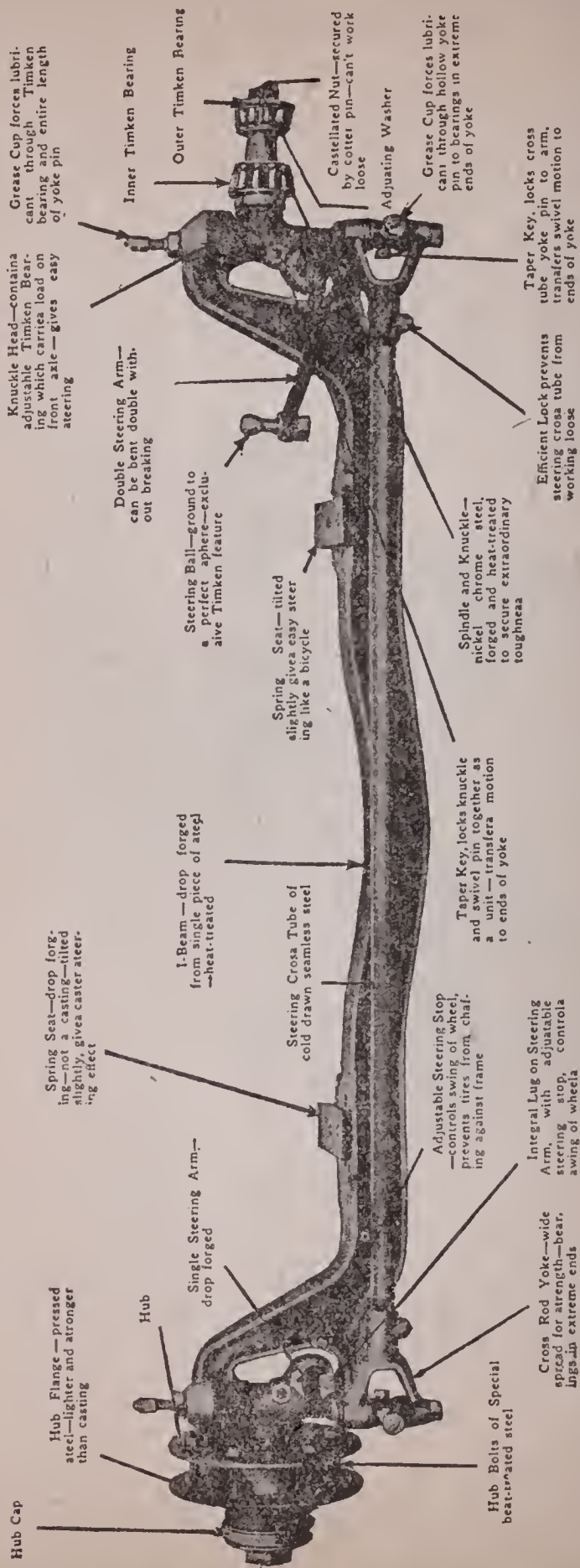


Fig. 47.—Pouring oil into the differential housing.

latter being at the rear end of a “pinion-shaft” coupled with the main propeller shaft which transmits the power from the engine.

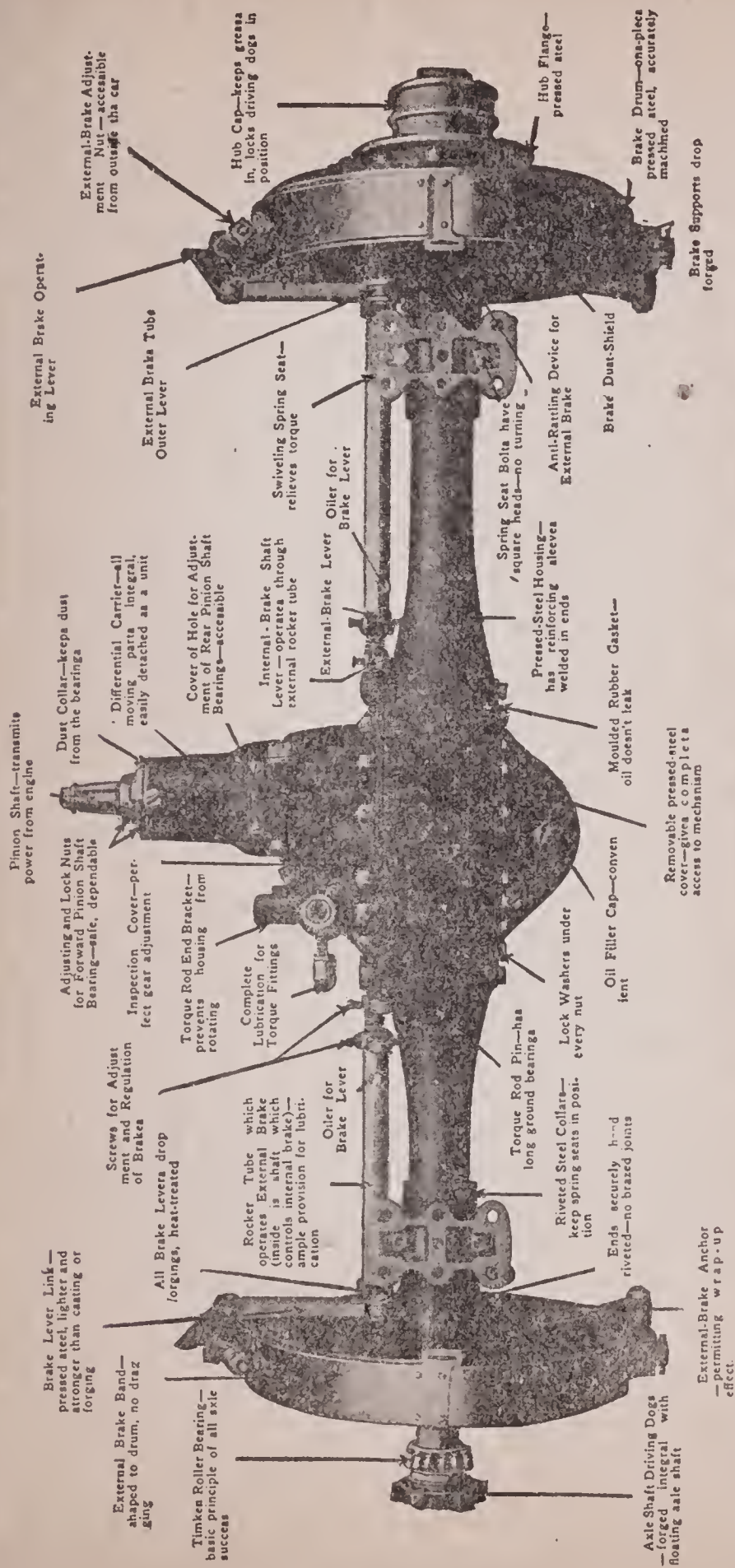
LUBRICATION.

Grease-cups are provided at every moving surface. They are shown on the diagrams and are readily found on the axles themselves.



Timken Detroit Front Axle.

Fig. 43.—Careful reading of the lettering on this picture will be well worth while. It tells you the names of the important parts of a Front Axle.



Timken Detroit Rear Axle.

Fig. 49.—This shows you some of the important features of a Rear Axle.

Make certain that every grease-cup is well filled with a high-grade, light grease, positively free from acid and from grit. Care in turning up the cups regularly cannot atone for oversight in not filling a cup with grease.

Keep your supply of grease in a tightly-covered can so that no grit or dust can get into it. If, by any chance, grit does get into the bearings or gears, the only thing to do is to wash them out thoroughly with kerosene and dry them; after which, clean grease should be applied.

In the rear cap of the differential housing is a plugged hole. Remove the plug and pour heavy oil in through the hole until it begins to come out. You will then have just the right amount of lubricant and can replace the plugs.

Specific directions as to how often to turn up the various grease-cups in order to force grease into the moving parts are impossible, because the periods of time will vary according to the amount of use of the car.

It is even impracticable to direct that one turn of the cup should be given every so many miles of travel, because so much depends on the grade of the grease and on conditions of weather and load.

There is just one simple rule to follow, viz.: force the grease forward in small amounts often, rather than in large quantities seldom; and err on the side of too much rather than too little. Grease is cheaper than bearings or gears.

Motor Car Brakes.

A MOTOR vehicle, which has been set in motion, must be brought to a state of rest under varying conditions, and this is invariably accomplished in absorbing the energy of the vehicle by friction. This friction is obtained by bringing a band which is held stationary into frictional contact with some revolving part of the vehicle. The motor car is essentially a high-speed vehicle and requires powerful and dependable brakes for its operation. The drum type of brake is most generally used. This consists of steel drum secured to either the road wheel or some other revolving part of the driving units, such as the propeller shaft and an expanding or contracting member secured to the vehicle frame or axle housing which can be brought into contact with brake drum. The energy dissipated in heat at the friction surface of the drum is withdrawn from the kinetic energy stored in the moving vehicle, and the speed of the vehicle decreases as its store of kinetic energy is depleted.

There is little uniformity in brake construction, except that certain states have laws which specify that these vehicles must be equipped with two brake systems, one for ordinary use and the other for emergency purposes.

BRAKE LOCATION.

The brakes may be fitted to either the front or rear wheels. The rear wheel position possesses an advantage, in that, as a rule, the rear wheels support much more of the weight of the car and the load than the front wheels, and since

the braking power depends upon the adhesion of the wheel to the road surface, which is dependent upon the weight carried, it can readily be seen that these possess a greater limiting power than the front wheels. The rear wheel position also greatly simplifies the brake operating mechanism.

In shaft-driven vehicles both sets of brakes may be located in the rear wheels, or one set may be so located and the other may be arranged to act on a drum located at either end of the propeller shaft. The latter location possesses a disadvantage, in that the reaction due to the frictional force on the brake drum takes place a considerable distance from the rear wheel, and the closer the application of the braking force the fewer parts are subjected to strain. With the transmission location, this strain must be transmitted through the propeller shaft, universal joint, bevel gears, axleshaft and hub connections. One advantage of this location is that, since the force is multiplied by the rear axle reduction, a great retarding effect can be produced with little effort.

ARRANGEMENT OF BRAKES.

One set of brakes is generally designated as the service brake and is intended for all ordinary occasions. This is generally operated by a foot pedal lever, as this permits the operator to keep one foot on the brake pedal all the time, which enables him to operate it without much effort. The other brake is called the emergency and intended for use when the service brake fails or when an exceeding great braking action is required. This is most generally operated by a lever at the driver's side, or in some cases by a foot pedal having a ratchet lock.

BRAKE LOCATION.

There are two arrangements of double rear

wheel brakes, which are in practical use, viz., two internal brakes acting on the same drum, one internal and one external acting on the same drum. When a transmission brake is used, but one set is placed on the rear wheels, and this is usually of the internal type.

TYPES OF BRAKES.

There are two general types of brakes, the band and shoe types, and either may be made expanding or contracting. The band type consists of a continuous steel band having a fabric frictional facing such as raybestos, multibestos, non-burn, etc., while the shoe type may either be of cast-iron or bronze, with cork inserts, as it may be provided with a fabric frictional facing.

These shoe type brakes may also be used without facings or cork inserts, but in this case they are provided with diagonal grooves to prevent chattering and squeaking.

The drums are invariably made of pressed steel, as this reduces the weight to a minimum as well as the cost. They are usually bolted to the wheels and in some cases form the rear wheel hub flange. This also applies to the transmission brake; however, in this case they must be bolted to the universal joint hub.

DOUBLE INTERNAL BRAKES.

Fig. 50 illustrates a double internal brake which is used on a number of motor cars. It is of the shoe type, provided with a frictional lining. These shoes are made in halves and are hinged to a spider riveted to the rear axle housing which forms the stationary member. The other end of the shoe rests on a cam, which when operated by the pedal causes the shoes to expand and to grip the brake drum through frictional contact, creating a retarding force on the wheels. Springs are used to hold the shoes in

contact with the cam and the hinge, while the facing is riveted to the periphery of the shoes. These brakes are located side by side and the brake spider has a pressed steel disc riveted to it, which completely encloses the brakes. No adjustment is provided, so the brake linkage to the pedal must be relied upon to take up the wear of the facing.

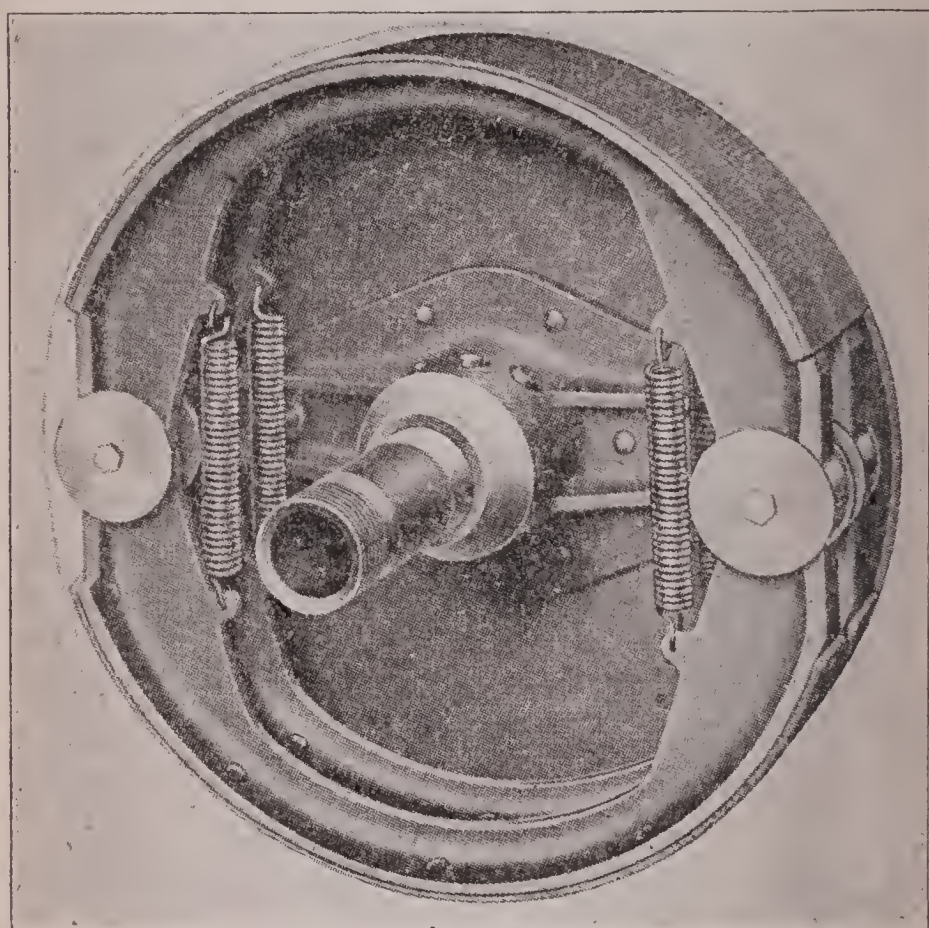


Fig. 50.—Double Internal Brakes.

THE INTERNAL AND EXTERNAL BRAKE.

This type (Fig. 51) is also used by a number of popular-priced cars. However, the construction of the internal brake is somewhat different from that described above. Instead of shoes, a continuous band is employed which has a frictional facing riveted to it and also brackets which

bear against a pin extending from the brake spider which acts as the anchorage. Two small toggle levers are attached to these brackets, which connect with a large link operated by the brake lever. The external brake is also of the continuous band type; however, it operates on

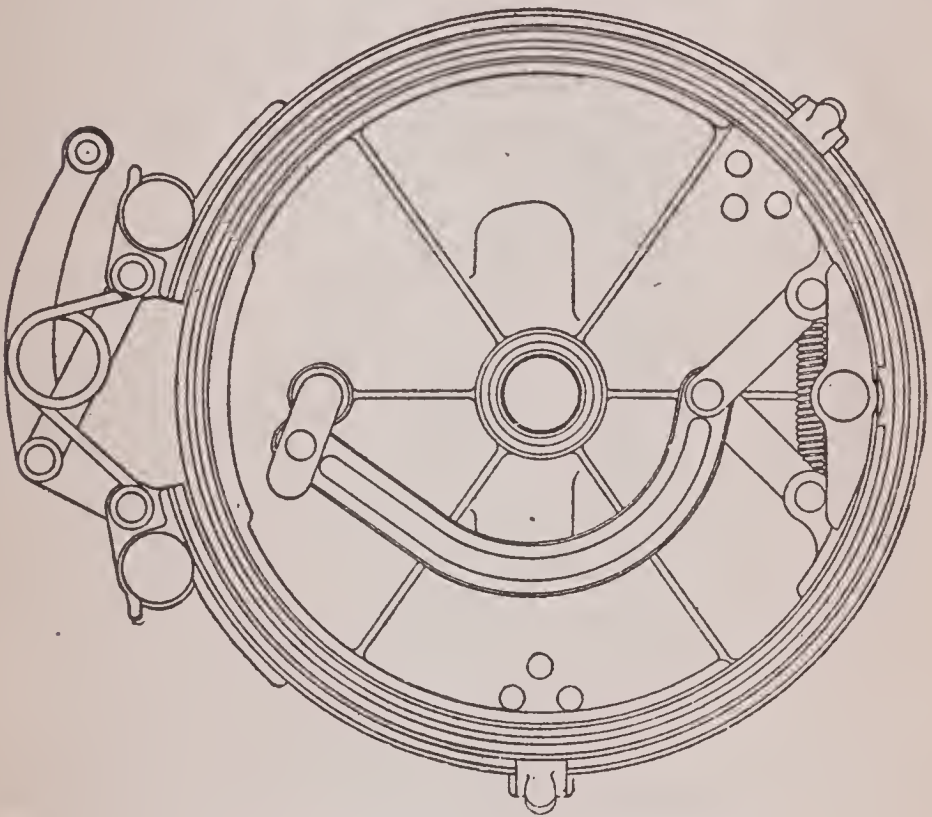


Fig. 51.—Internal and External Brakes.

the external side of the drum and is made contracting instead of expanding. It is operated through a toggle connection with the brake lever. In this construction adjustment must also be made in the brake linkage.

ADJUSTABLE BRAKES.

Fig. 52 illustrates the internal and external brakes used on the White motor cars, which are provided with an adjustment for taking up wear. The internal brake is operated by a cam, while the external is operated through a toggle linkage.

The cam for operating the internal brake bears against two hardened steel members, "B," which may be adjusted in or out and locked by the screw, "A," while screw, "C," is used to equalize the clearance at either end of the brake drum. The adjustment of the external brake is

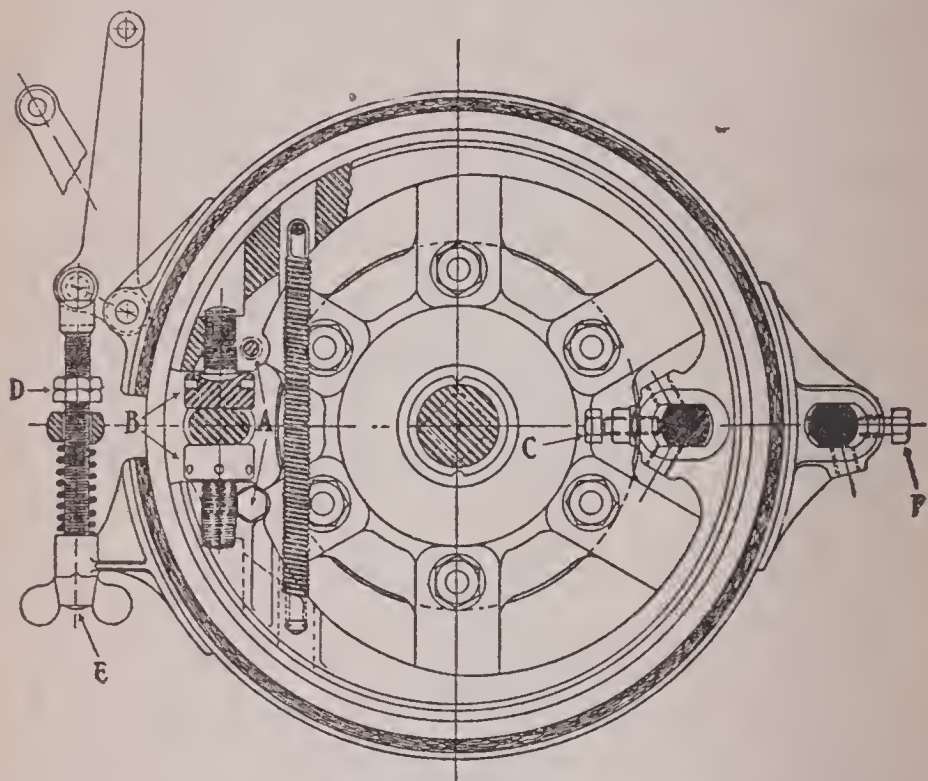


Fig. 52.—White Internal and External Brakes, provided with Adjustment.

quite simple. This is accomplished by adjusting the screw "F" to give the proper clearance at the anchor and raising or lowering the jam nuts "D" until the band has proper clearance, then the wing nut permits proper adjustment.

Transmission brakes are usually of the external contracting type, and an excellent example of this is shown in Fig. 53. The brake drum is bolted to the universal joint hub at the rear end of the transmission. The brake is of the band type with a fabric frictional facing, although it may also be of the shoe type. This brake is anchored to and supported from the gear box,

which also supports the brake pedal. The knurled screw "A" provides an adjustment for taking up wear.

BRAKE ADJUSTMENTS.

Brake adjustments are necessary, as the fabric facing material wears in the course of time. In some cases this is provided in the mechanism used to contract or expand the brake, while in

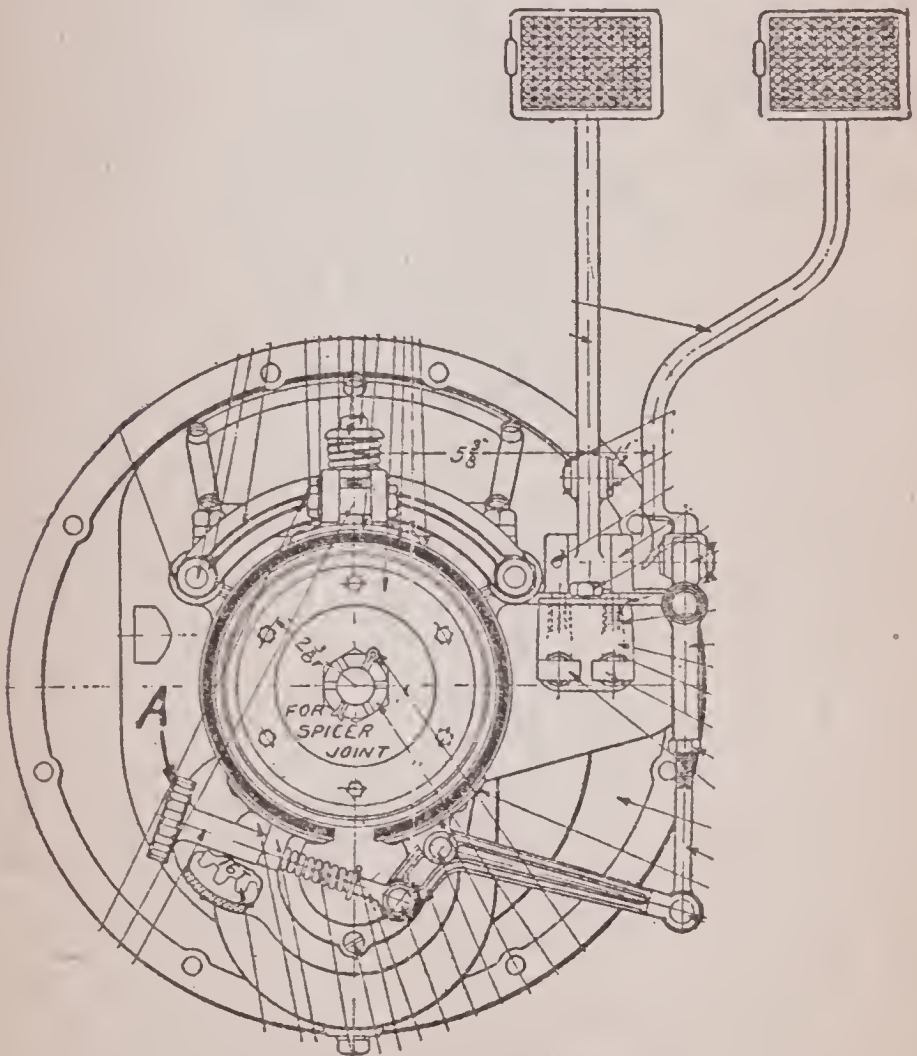


Fig. 53.—Transmission Brake.

others the adjustment is incorporated in the brake-rods or pedal connections.

BRAKE EQUALIZERS.

Brakes on opposite wheels must produce equal

retarding, for with unequal retarding effects the car has a tendency to skid. In order to accomplish this equal retarding effect on rear wheel brakes, it is necessary to apply equal operating forces. This necessitates an equalizing device in the brake operating linkage, which usually takes the form of a balance lever. The balance lever or equalizer consists of a flat piece of steel, having a brake-rod connection from each wheel attached to its ends, while a connection from the

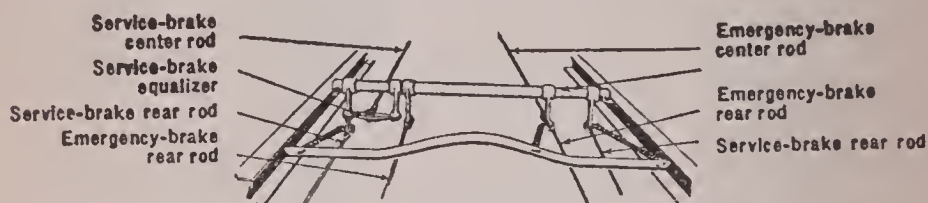


Fig. 54.—Modified Whipple-tree Equalizer.

pedal is attached at the center. This is sometimes termed a whipple-tree equalizer. A modified form of whipple tree equalizer is shown in Fig. 54, being connected with the brake levers. With a transmission brake it is not necessary since the differential take care of the equal distribution.

The Carburetor

CARBURETION is a term not usually clear to the lay mind. This may be defined as the vaporization of the fuel and the mixing of gasoline and air in the proper proportion to produce the explosive mixture drawn into the cylinders.

The proportion of gasoline and air, of course, depends upon conditions, although seventeen parts of air to one of gasoline is considered an average proportion. The purpose of this quantity of air is to supply oxygen for combustion, and the quantity of oxygen supplied necessarily controls the number of parts of air to gasoline. Varying temperatures of the air mean varying quantities of oxygen, while the ratio of air to gasoline is also dependent upon the quality of the gasoline.

The correct proportioning of the air and the fuel is of great importance. If there is too much or too little gasoline within relatively narrow limits the action of the engine becomes objectionable. This condition is found when the term lean or rich mixture is mentioned.

It is possible to vaporize the liquid fuel in two ways—by heat and by vacuum. Vaporization of the liquid fuel by vacuum is only partly complete, for no matter how far the process of reduction goes, since the liquid which vaporizes does so by the abstraction of heat from the remainder, and this, of course, becomes colder until finally the temperature is so low that vaporization ceases until heat is again supplied from some other source. When vaporization is brought about by heat, the degree depends upon the amount of heat

supplied, since the liquid is constantly raised to or maintained at the proper degree.

In actual practice neither of the above vaporization methods are carried to the limit, but both are applied together. Each of these vaporization actions help the other, namely, the air supplies heat to the liquid as it is cooled by vaporization under reduced pressure and due to pressure reduction, helping the transfer of heat from the air to the liquid.

All of the above is carried out in an instrument which is known as the carburetor. Gasoline is fed to the carburetor through a small pipe, which is commonly called the supply pipe, from the gasoline or fuel tank, which may be located in several different positions. It may be located either in the cowl, under the front seat, or at the rear end of the chassis. From the tank the gasoline enters the carburetor through what is known as the float chamber, passing through a strainer and by a needle valve, which performs the functions of stopping the flow when a predetermined level is reached in the float chamber. This needle valve is governed by the action of the float, which rises as gasoline enters, these two units being connected by a suitable mechanism.

The gasoline in the float chamber must be kept constant, so as to prevent it from flowing over the jet which, if permitted, will cause faulty running of the engine. The action of this float is quite similar to a ball type of water trap, for as the ball rises it shuts off the flow of water, and as the float rises it brings the needle valve to its seat and shuts off the gasoline. These floats may either be made of cork or metal. The metal float must be made air-tight and hollow, so as to be sustained in the liquid. Cork floats are usually covered with shellac to prevent them from ab-

sorbing some of the liquid and becoming too heavy.

The choke or strangling tube in the mixing chamber allows a current of air to pass by the jet which draws with it a proportion of gasoline spray, and as the gasoline and vapor reaches the intake manifold, it becomes a gaseous mixture, and enters the engine cylinders through the intake valve on the downward stroke of the piston. Directly under the flange connecting the carburetor with the intake manifold is located a butterfly valve, which controls the amount of gas entering the cylinders. Opening this valve permits the engine speed to increase, providing the mixture is proportioned properly. An increase in motor speed creates an increase in suction on the carburetor jet and increases the amount of gasoline issuing from the jet. This, of course, will give an overly rich mixture unless some means are provided for allowing more air. This is usually compensated for by an auxiliary air valve which is controlled by a spring, so that as the suction is increased more air is permitted to enter.

There are a great many different carburetors used at the present time. Some of these control the proportions by raising the needle valve with increased engine speed, such as the Breeze and Schebler carburetors, while others control the air, such as the Kingston, K. D., Strömberg and others. Some carburetors also work automatically.

In presenting this treatise it is quite difficult to describe every instrument made. However, an effort will be made to describe a number of the leading types which are classed as standard makes and used on quite a number of motor cars.

Several illustrations are also included of carburetors, which are built by motor car builders to meet the peculiar requirements of their engines.

THE HOLLEY CARBURETOR.

Fig. 55 illustrates a sectional view of the model "H" Holley carburetor, which is provided with a free air opening and is so designed that the air is controlled by the suction of the engine. Before the fuel enters the float chamber it passes the strainer disc "A," which removes all foreign matter that might interfere with the seating of the special alloy-tipped float valve "B" under the action of the laminated cork float and its lever "C."

Fuel passes from the float chamber "D" into the nozzle well "E" through a passage "F" drilled through the walls separating them. From the nozzle well the fuel enters the nozzle proper "G" through the hole "H," and rises past the needle valve "I" to a level in its cup-shaped upper end, which just submerges the lower end of the small tube "J," which has its outlet at the edge of the butterfly valve.

Cranking the engine with the throttle kept nearly closed causes a very energetic flow of air through the tube "J," and its calibrated throttling plug "K." But the lower end of this tube is submerged in fuel with the engine at rest. With the motor turning over under its own power, flow through the tube "J" takes place at a very high velocity, thus causing the fuel entering the tube with the air to be thoroughly atomized upon its exit from the small opening near the butterfly valve. This tube is called the "low speed tube" because for all starting and idle running all of the fuel and most of the air in the working mixture are taken through it.

As the throttle opening is increased beyond that needed for idling of the motor, a considerable volume of air is caused to move through the passage bounded by the conical walls "L" of the

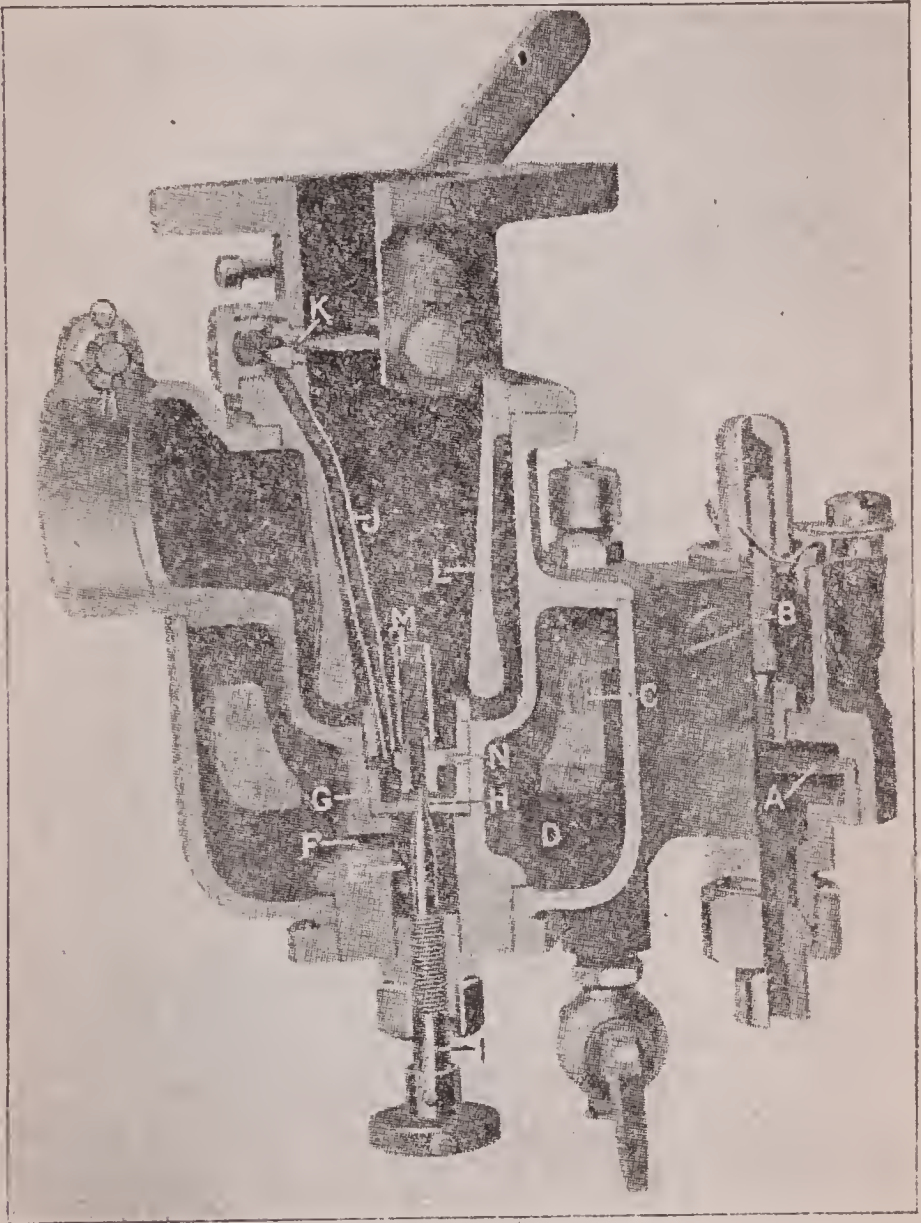


Fig. 55.—The Holley Model H Carburetor.

so-called strangling tube. In its passage into the strangling tube the air is made to assume an annular, converging stream form, so that the point in its flow at which it attains its highest velocity is in the immediate neighborhood of the stand-

pipe "M," set on to the body of the nozzle piece "G." The velocity of the air flow being highest at the upper or outlet end of the standpipe, the pressure of the air stream is lowest at the same point. For this reason there is a pressure difference between the top and bottom openings of the standpipe "M," thus causing air to flow through it from bottom to top.

With very small throttle opening, the action through the standpipe (air passing downward through a series of openings "N" in the standpipe supporting bridge) keeps the nozzle cup thoroughly cleaned out, the fuel passing directly from the needle opening into the standpipe.

THE ZENITH CARBURETOR.

In the Zenith carburetor, Fig. 56, the ratio of gasoline to air is kept almost constant during the entire range of motor speed by what is termed a compensating nozzle, which counteracts the mixture fed by the main nozzle. The main jet "G," has another around it, "H," which is fed by a well, "I," which in turn is fed by the float chamber. Gasoline enters the strainer body "D," passes through the wire gauge "D 1," and enters the float chamber through the valve seat "S." As soon as the gasoline reaches a predetermined height in the float chamber, the metal float, "F," acting through the levers "B" and collar "G 2," closes the needle valve, "G 1," on its seat. From the float chamber to the motor gasoline flows through three different channels, in various quantities and proportions, according to the speed of the engine and to the degree of throttle opening. With the throttle fully open, most of the gasoline flows through compensator "I," then through plug "K" to the cap jet "H," which surrounds the main jet. This main jet and cap jet work together and their combination furnishes

the mixture, whatever be the speed of the engine. At low speed when the butterfly valve "T" is nearly closed, they give but little or no gasoline, but as there is considerable suction on the edge

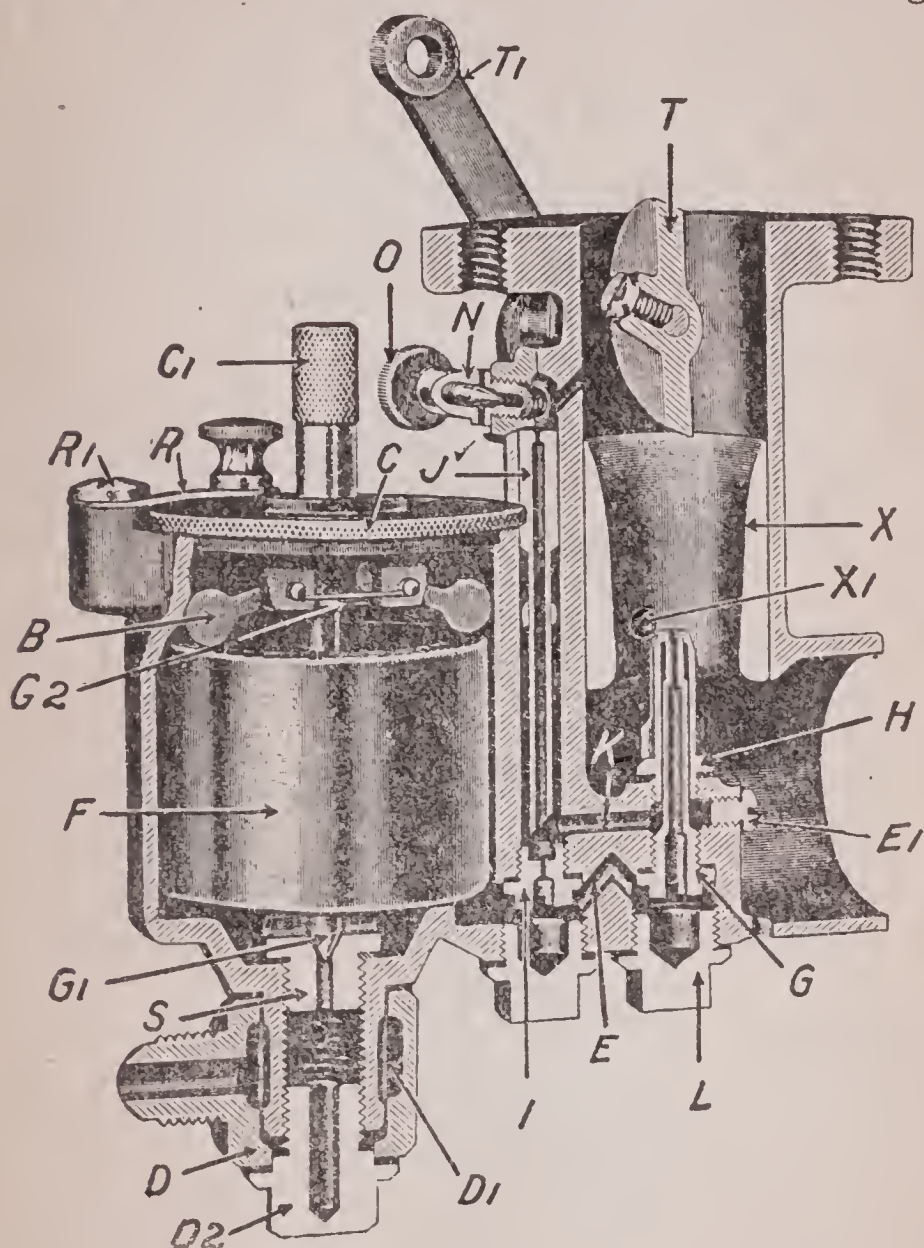


Fig. 56.—The Zenith Model "O" Carburetor.

of the butterfly valve, the tube "J" terminating in a hole near the edge of the butterfly valve, picks up gasoline, which is measured out by a small hole at the top of the priming plug. The well over compensator "I" is open to the air through two holes, one of which is indicated below the priming plug on the illustration.

THE MARVEL CARBURETOR.

This instrument, Fig. 57, like most ll other instruments, consists essentially of a float chamber and a mixing chamber. Gasoline enters the float chamber and is filtered again before it reaches the needle valve and the low speed spray nozzle, when it stands at the same height as in the float chamber. All the air supplied to this instrument enters through one opening on the right marked

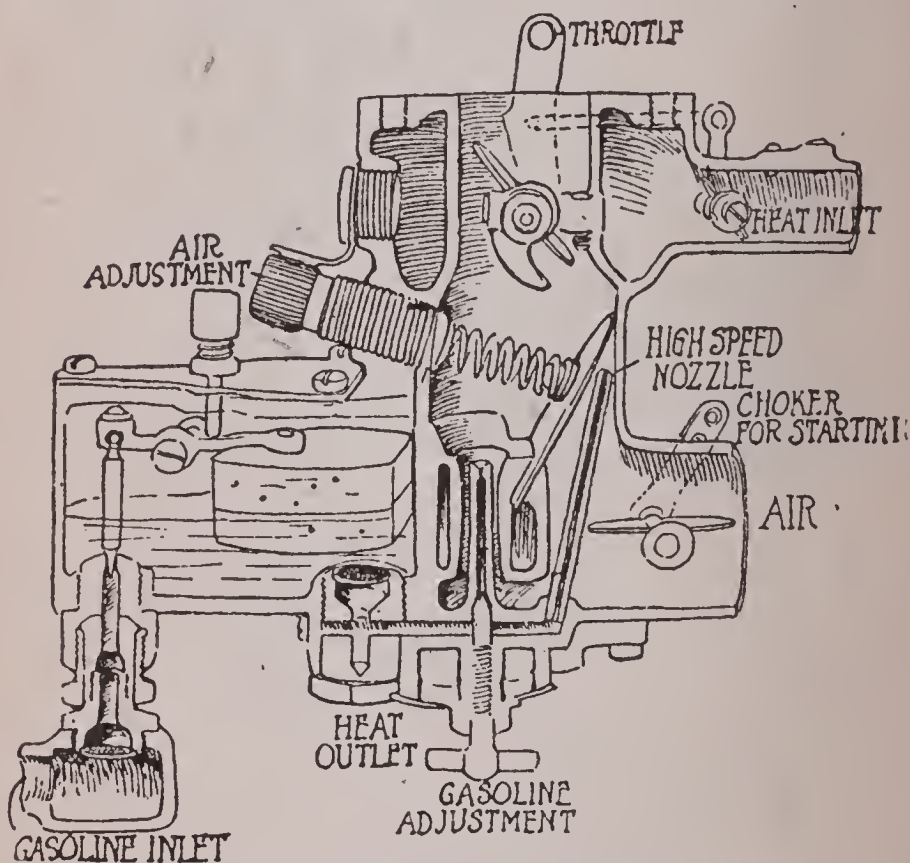


Fig. 57.—The Marvel Carburetor.

“air inlet.” After it has passed the choker it divides, part of it going through the venturi tube, around the low speed spray nozzle, and the remainder passing above and opening the auxiliary air valve against its spring. Near the top and underneath the auxiliary air valve is located the secondary or high speed spray nozzle.

The speed of the motor and the condition of the throttle directly effect the proportioning of

the incoming air, as it passes through each of these courses. At low speed and nearly closed throttle the suction of the motor is very light, so that practically all of the air passes through the venturi tube. As the speed and suction of the motor increases with the throttle opening the auxiliary air valve is lifted from its seat and a larger proportion of air enters the intake manifold through this passage.

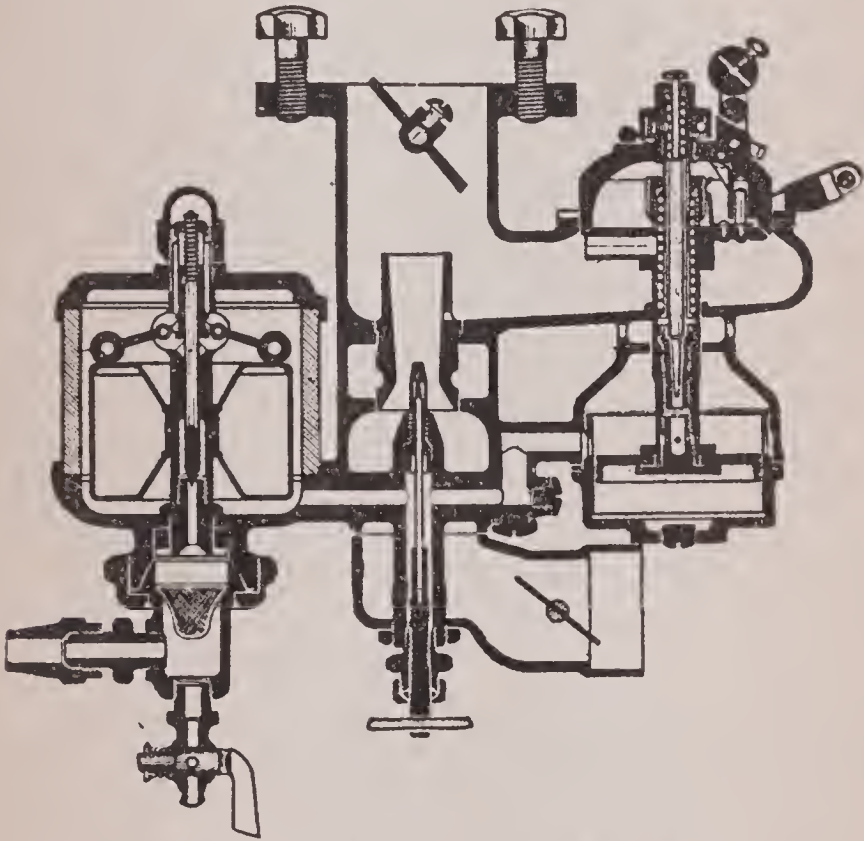


Fig. 58.—The Stromberg Carburetor.

The rush of air through the venturi tube picks up and vaporizes gasoline from the low speed spray nozzle and carries it past the throttle and through the intake manifold to the cylinders. When the suction at the auxiliary air valve has increased sufficiently to create a high velocity at this point, gasoline is also picked up from the high speed spray nozzle and carried into the cylinders in the same manner.

THE STROMBERG CARBURETOR.

The Stromberg carburetor, shown in Fig. 58, also has two adjustments, a high and a low speed, both working directly in the gasoline supply, that is, the low speed adjustment is by the needle valve and the high speed by the air valve. The gasoline for low speed is taken from the spray nozzle, located in the venturi, through which the heated air passes. There is also a second nozzle

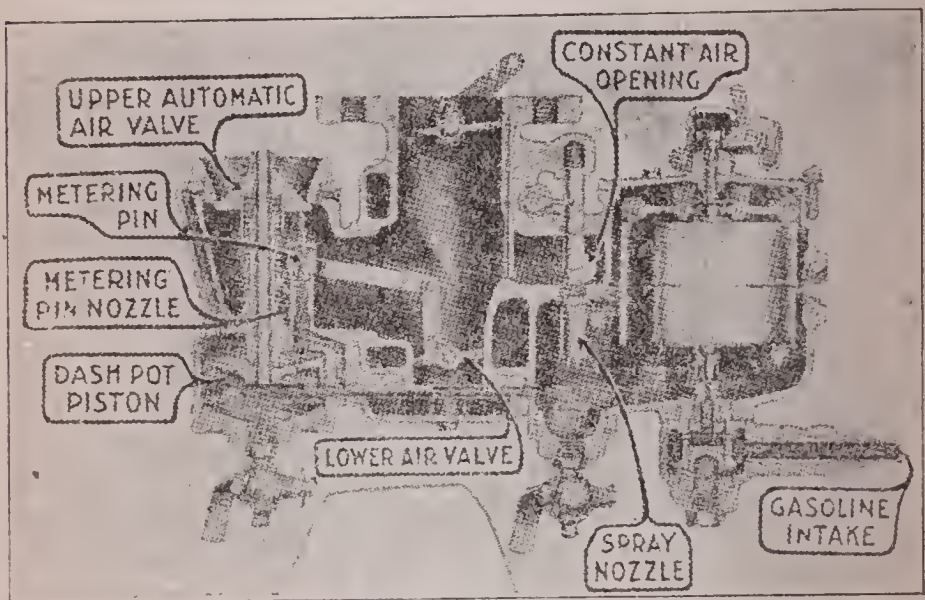


Fig. 59.—The Rayfield Carburetor.

in the center of the air valve, which is automatically regulated by the opening of the air valve, thus supplying the necessary volume of gasoline for high speed. This air valve terminates in a dash pot, which eliminates all fluttering, as it is submerged in a puddle of gasoline supplied from the float chamber. This carburetor has a somewhat different float mechanism than those depicted above, in that the float valve passes through the float, which is metal.

THE RAYFIELD CARBURETOR.

This instrument, Fig. 59, is of the dash pot type. The fuel in this type is taken in above

the piston and is fed to the metering pin nozzle from below the piston. From the illustration it will be noted that the floating piston or dash pot has a crank valve. This valve causes slow opening and quick closing of the air valve. Air is supplied through three openings, constant air opening, lower air opening and upper automatic air valve. Gasoline is supplied through a main nozzle and the auxiliary metering pin nozzle. At low motor speed two air openings are closed and all the air is taken in through the constant air opening. The automatic air valve controls both of the auxiliary air openings and is directly connected to the dash pot. This dash pot operates in a puddle of gasoline, which is maintained constantly through a passage from the float chamber. Gasoline is drawn from this dash pot to the metering pin nozzle. The dash pot performs three purposes. It prevents the air valve from fluttering during accelerations, it retards the opening of the air valve for a few seconds when the throttle is opened, giving a quick pick up. When the upper automatic air valve starts to open it pushes the dash pot piston down, forcing the gasoline up through the metering pin nozzle, spraying it out into the mixing chamber, when the air and gasoline become mixed to an explosive mixture.

The Magneto

In order to get a good understanding of the method of producing electricity by magnetos, it is necessary to review some of the fundamental steps in the way of the most important discoveries.

Even in the times when little was known about electricity, a certain relation was discovered between electricity and magnetism, and by the experiments of Faraday, Ampere, Davy and Oersted it was discovered that whenever a current of electricity is passed through a conductor there are magnetic lines of force around the conductor exactly the same as the lines of force between the poles of a magnet. The space around the conductor which is influenced by this force is called the "magnetic field."

By placing a magnetic needle near a wire through which an electric current is passed it will be noticed that the needle is deflected, tending to point perpendicularly toward the wire. In 1831 Faraday published his discovery of the corollary principle that passing a conductor through a magnetic field so that the conductor cuts through the lines of force, causes an electrical pressure to be induced in the conductor, the direction of the flow of current bearing a fixed relation to the direction in which the conductor is moved in the field. The rule governing these relations can easily be remembered by studying the illustration of the hand. Fig. 61 will illustrate how the direction of the current changes every time the armature moves 180 degrees through the field, producing what is known as an alternating current.

The part which is moved through the field is called the "armature" and in a magneto the core

of the armature is in the form of an "I." In a high tension magneto there is wound around the core first one coil of wire, which is called the "primary coil," consisting of a comparatively few turns of heavy wire, and on the outside of the primary winding is the secondary winding, consisting of a great many turns of fine wire.

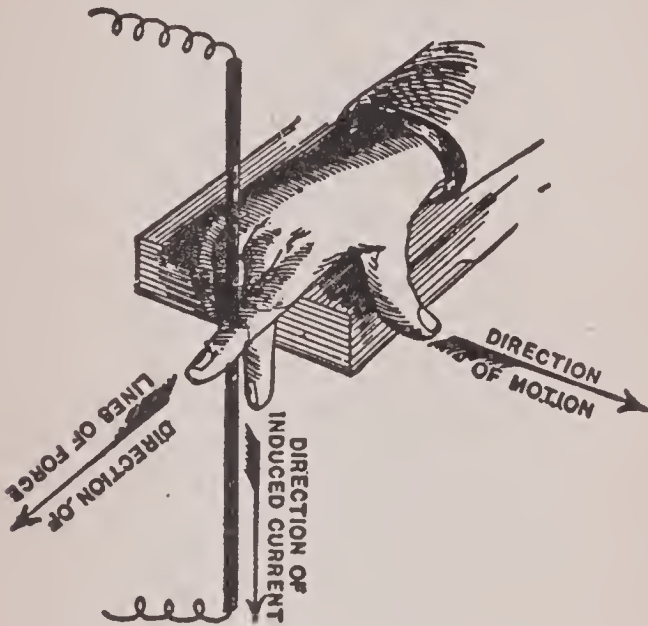


Fig. 60.—The hand rule for determining direction of induced current.

In a low-tension magneto this secondary winding takes the form of a coil which is located outside of the magneto. Without the secondary winding only a current of low voltage can be obtained, and since a high voltage is required to make the current jump the gap in the spark plugs, a secondary winding in some form is necessary. The greater simplicity of the high-tension magneto in this respect is obvious, and in addition to the simplicity, the spark produced by the high-tension magneto is superior for ignition purposes on account of diminished loss of current by resistance in the wires.

Experiments have led to the discovery that by passing a current through a coil of wire around

which a second coil is wound, a current of high voltage is induced in the outside coil *at the moment the primary current is broken*. So the necessity of a device which will break the primary current when a spark is desired in the secondary coil is apparent. This device is called the "breaker."

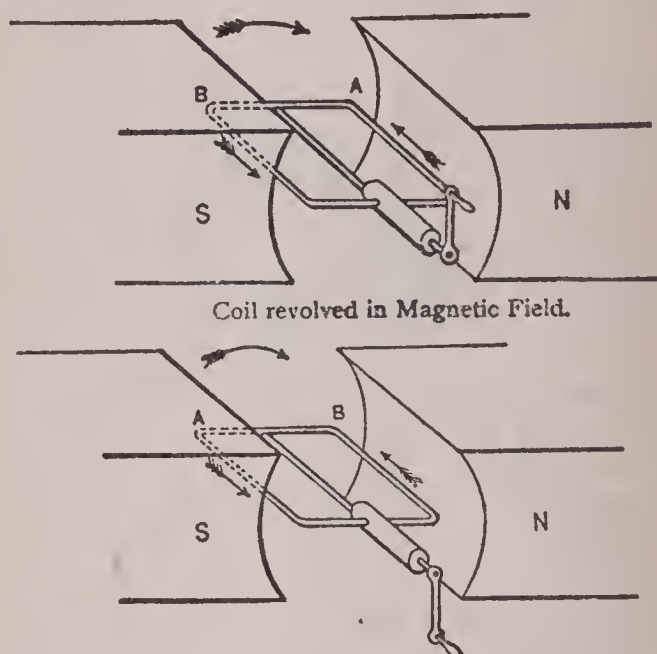


Fig. 61.—Coil revolved in magnetic field.

THE CIRCUIT BREAKER.

This circuit breaker generally consists of stationary and movable contact points which are ordinarily kept in contact by a spring. The breaking effect is usually accomplished by a cam which suddenly separated the contact points.

When these two contacts are suddenly separated there is a tendency for the current to continue to flow across the gap. This results in a hot spark being formed, which will not only burn the points away, but will also prevent a rapid cessation of the current.

THE CONDENSER.

To avoid this a condenser is built into the magneto, which consists of two sets of tin-foil

sheets, sheets of opposite sets alternating with each other and separated by insulating material. One set is grounded, while the other is connected with the primary winding. These condensers are capable of absorbing an electrical charge.

THE SAFETY GAP.

The electromotive force of the secondary winding is always limited to the size of the gap in the spark plug; however, should the plug gap be too large for the sparks to pass, this force might build up to such a point as to puncture the insulation of the windings. A safety gap which is larger than that of the plugs is usually provided, which will permit a discharge and prevent the electromotive force from rising still higher.

THE SWITCH.

The switch serves the function of cutting out the circuit breaker, and the priming winding is short circuited all the time, so that the opening and closing of the contact points has no effect.

MAGNETO TYPES.

There are two types of magnetos as mentioned above—one in which the secondary winding is placed on the armature, and the other in which this is placed in coil located outside of the magneto. Both, however, are termed high-tension units, and furnish a jump spark.

CLASSIFICATION.

This may be divided into two groups, according to the principle employed to generate the initial impulses in the magnetic field. These are generally termed the armature and conductor type. In the former electrical current is generated by revolving the armature and its windings between the pole pieces or shoes. The inductor

type consists of two fan-shaped inductor wings, which are mounted on a shaft and rotated within a stationary winding in the magnetic field.

THE SIMMS MAGNETO.

The armature of this magneto is of the true high-tension type, on which is wound both the low-tension primary and the high-tension secondary windings, connected in series. This instrument creates a high-tension current directly in

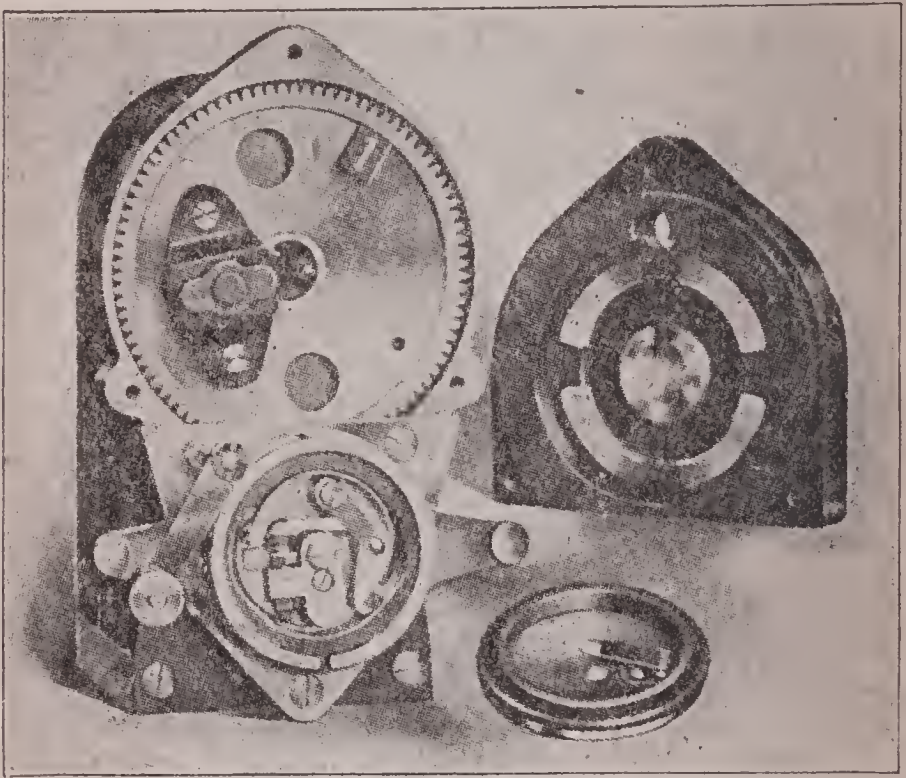


Fig. 62.—The Simms High Tension Magneto, showing Interrupter and Distributor.

the armature, and does not use any exterior coil or other device to step up or transform the current, as the instrument is a complete unit within itself.

The armature windings are heavily impregnated with an insulating substance of high dielectric strength, which thoroughly protects the armature against water, moisture or short cir-

cuits. This armature is mounted on high-grade annular ball-bearings, the idea being to eliminate friction and all difficulty due to insufficient lubrication.

The contact breaker interrupter cam ring is a one-piece, hardened and ground, which insures perfect synchronism at all speeds, and is accurate at all positions from full retard to full

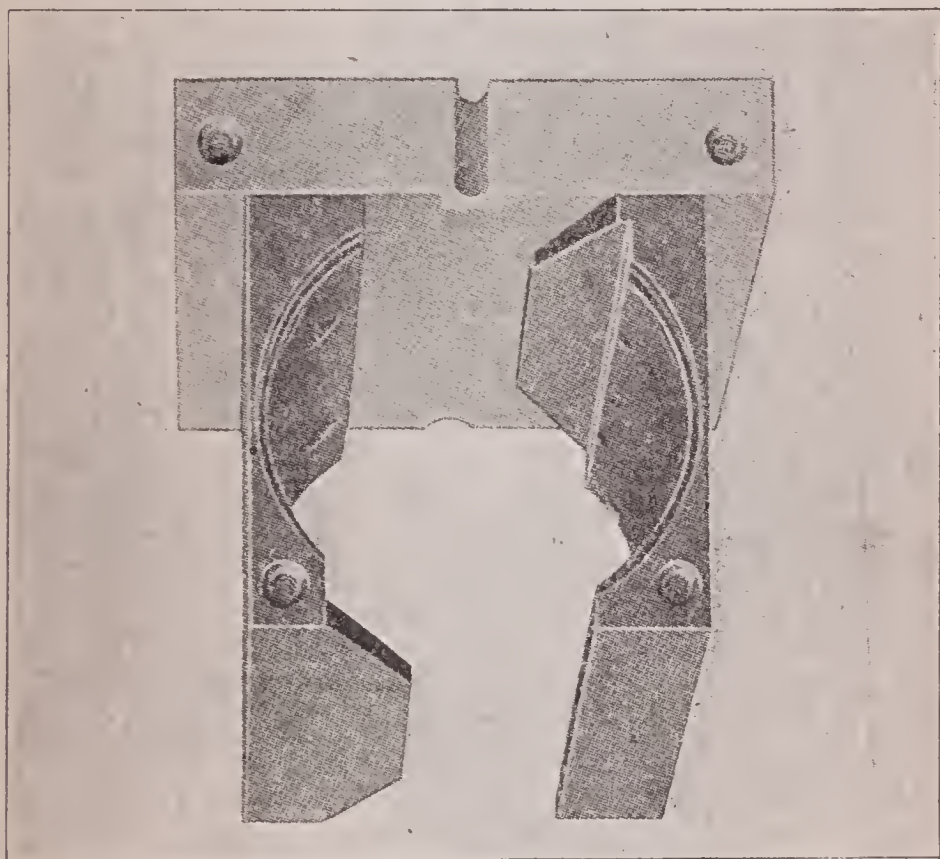


Fig. 63.—Extended Pole Shoe of the Simms Magneto.

advance. The platinum points are made exceptionally large, to provide long life. The contact breaker is made quite accessible, and can easily be removed for cleaning.

The distributor is located above the armature, being driven by gears. It is both dust and water proof, and made from a hard rubber substance which is claimed to be decidedly superior to any composition material. The distributor brush is made extra large, and the brass seg-

ments have an exceptionally wide surface, in order to reduce wear to a minimum. The distributor terminals are of the screw type, and located on the face of the distributor for securely fastening the terminals. This unit is so arranged that it can easily be removed for cleaning.

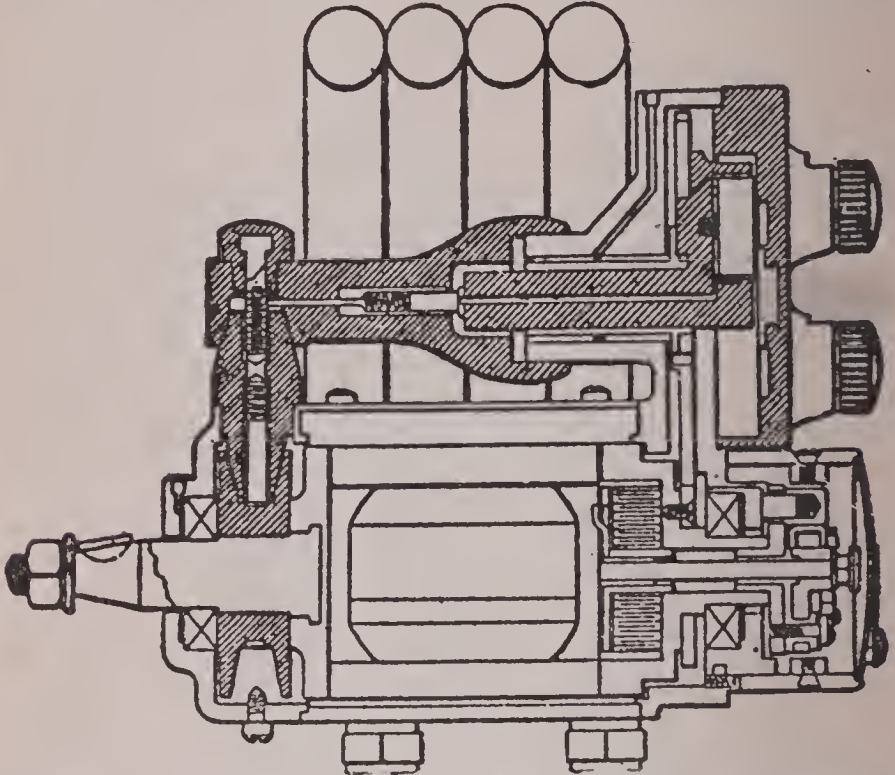


Fig. 64.—Sectional View of the Heinze High Tension Magneto equipped with Magnets of Circular Section.

A safety gap is also provided to prevent damage to the magneto, in the event of one or more high-tension cables becoming disconnected from the spark plugs. The gap is so located that its action may be readily observed for the purpose of locating trouble in misfiring.

One of the principle features of this magneto is the new form of extended pole shoe, which enables the magneto to produce a spark of unusual intensity at full retard or low speed. It is claimed that this feature was a disadvantage formally in starting on the magneto direct, and was facilitated by advancing the spark as far as was safe when cranking.

THE HEINZE MAGNETO.

Most all magnetos employ magnets of the horseshoe type, which are usually rectangular. However, in the Heinze magneto these are of round section, as illustrated. The pole pieces and the armature are also of the round type.

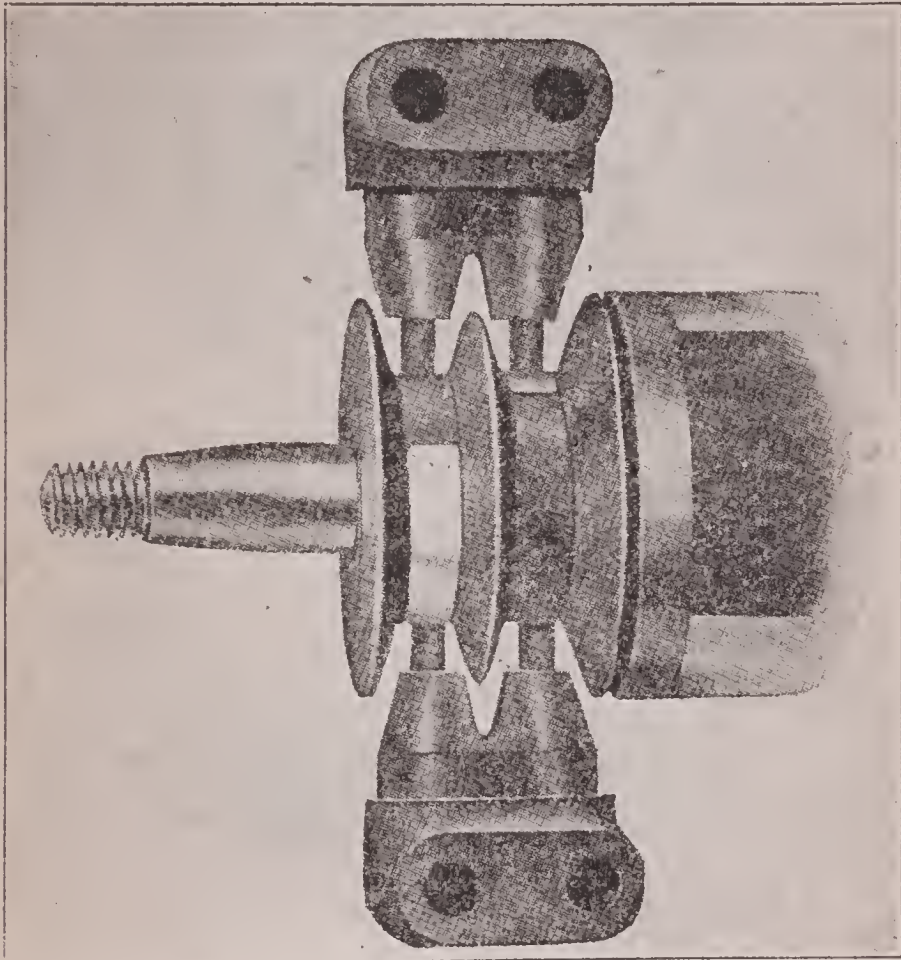


Fig. 65.—Method of setting Carbon Brushes in relation to the segments on the Bosch N U 4 Magneto.

The round type armature permits the minimum amount of wire in both the primary and secondary windings which cuts down the resistance, and, therefore, it is claimed gives a hotter spark. These round armature windings are assembled about a round iron core made up of a bundle of very small and correspondingly well-annealed soft iron wires. An arrangement for varying

the timing is fitted as in most all other types. The armature shaft is mounted on ball-bearings, while the contact breaker and distributor are mounted at the rear of the instrument.

THE BOSCH HIGH-TENSION MAGNETO.

The Bosch Company makes a number of high-tension instruments. However, the Model N. U. 4 will be described here, since it possesses several

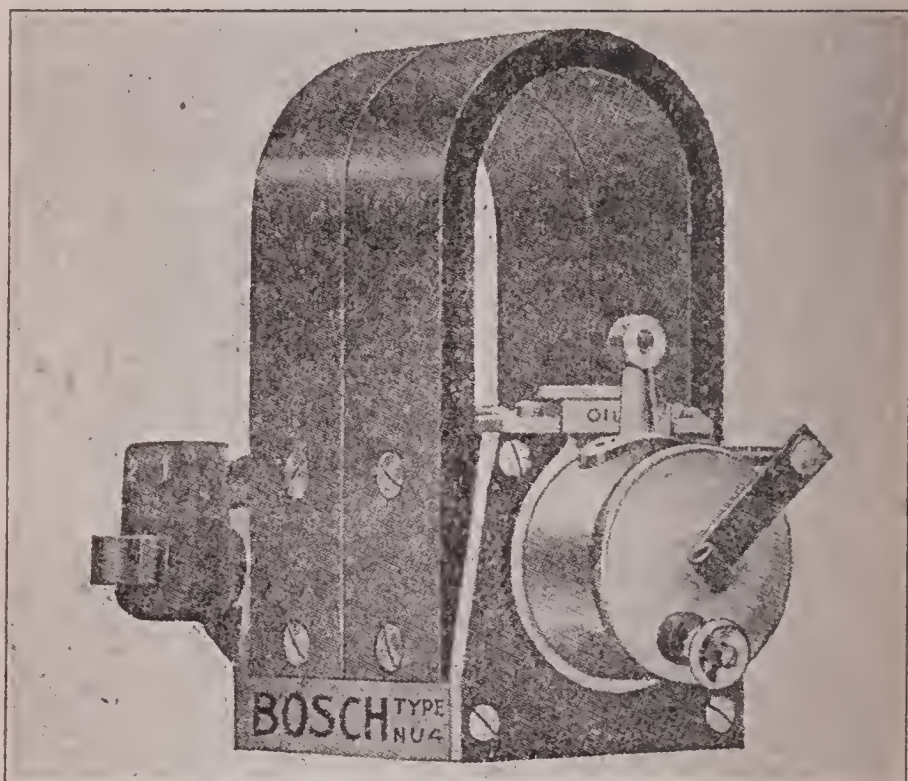


Fig. 66.—New Bosch Type N U 4 Magneto.

features which are not incorporated in the other types.

Like all other Bosch instruments, the armature carries the primary and secondary windings, which are in two portions, the primary consisting of a few layers of comparatively heavy wire, and the secondary consisting of many layers of fine wire. This primary winding has one end connected to the armature core, and the other end to the insulated contact block supporting the long platinum pointed screw on the

magneto breaker or interrupter. The interrupter lever, carrying a short platinum pointed screw, is mounted on the interrupter disc, which, in turn, is electrically connected to the armature core. The primary circuit, therefore, is complete whenever the two platinum points are in contact, and broken whenever the points are separated; and as high-tension current is generated only at each separation of these points, the importance of this breaker or interrupter is evident.

In the usual form of Bosch instruments, the secondary winding producing the sparking current is practically a continuation of the primary, its inner end connecting with the latter, and the other end leading to an insulated slip ring mounted on the driving shaft end and rotating with the armature. From the slip ring the high-tension current is collected by a brush and passed to the distributor.

In Model N. U. 4 there is absolutely no connection between the primary and secondary windings. These, in fact, are entirely insulated from each other, and the two ends of the secondary connected to two metal segments in a double slip ring attached to and rotated with the armature shaft. As the armature rotates the two slip-ring segments pass the current to four brushes, each of which is connected by its respective cable to a spark plug in the cylinders. The distribution of the high-tension current is thus effected without resource to the usual separate distributor.

THE MEA MAGNETO.

The distinct innovation and improvement incorporated in the Mea magneto consists in the bell-shaped magnet here illustrated, which is mounted horizontally and in the axis with the armature, instead of the customary horseshoe

magnets placed at right angles to the armature.

This makes possible and practical the simultaneous advance and retard of the magnets and breaker instead of the advance and retard of the breaker alone.

An additional feature of the bell-shaped magnet is its magnetic permanency. The life of a magnet is the greater the smaller its stray field.

From the diagram of the Mea magneto shown, the breaker can be seen at the end of the magneto

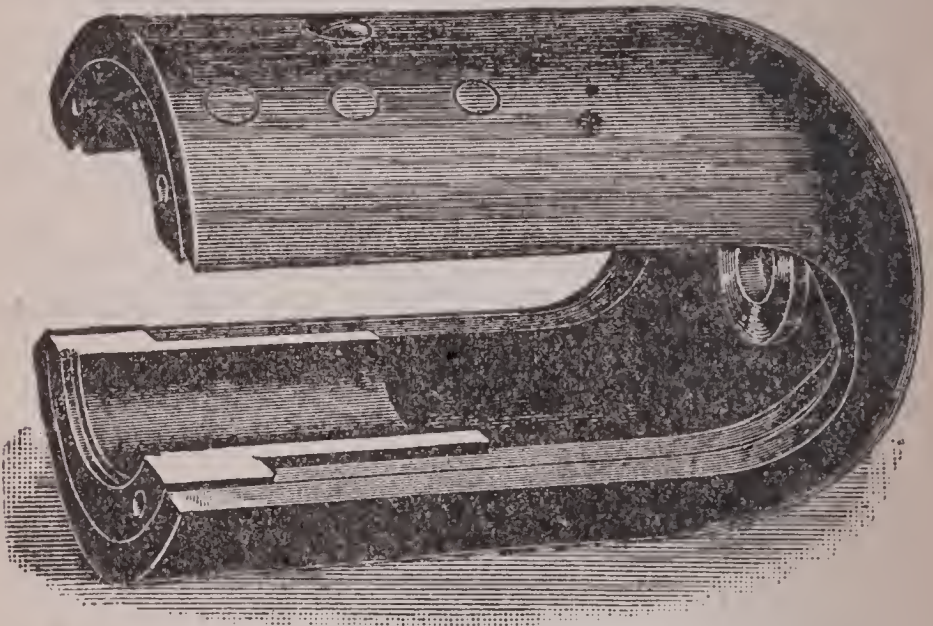


Fig. 67.—Bell-Shaped Magnet of the Mea Magneto.

opposite the shaft, and it will be seen that the fibre roller (31), which is actuated by a cam (40), presses the spring (30), carrying with it the platinum point (34), so that the primary current is interrupted between the two platinum points (34 and 33). At the moment when this current is interrupted a spark of sufficient intensity to burn off the ends of the platinum points would be produced if a condenser were not introduced. This is indicated by 12 and consists of layers of foil insulated from each other with paper, or mica.

As before stated, when the primary current is interrupted a high-tension current is produced in

the secondary coil, which is directly connected to the slip ring (4), and in turn is delivered to the high-tension carbon (77). This carbon is pressed against the slip ring by means of a light spring and the current passes through the carbon and into the knob terminal on top of the high-tension carbon holder. From thence it travels across the high-tension bridge (84) and down into the center

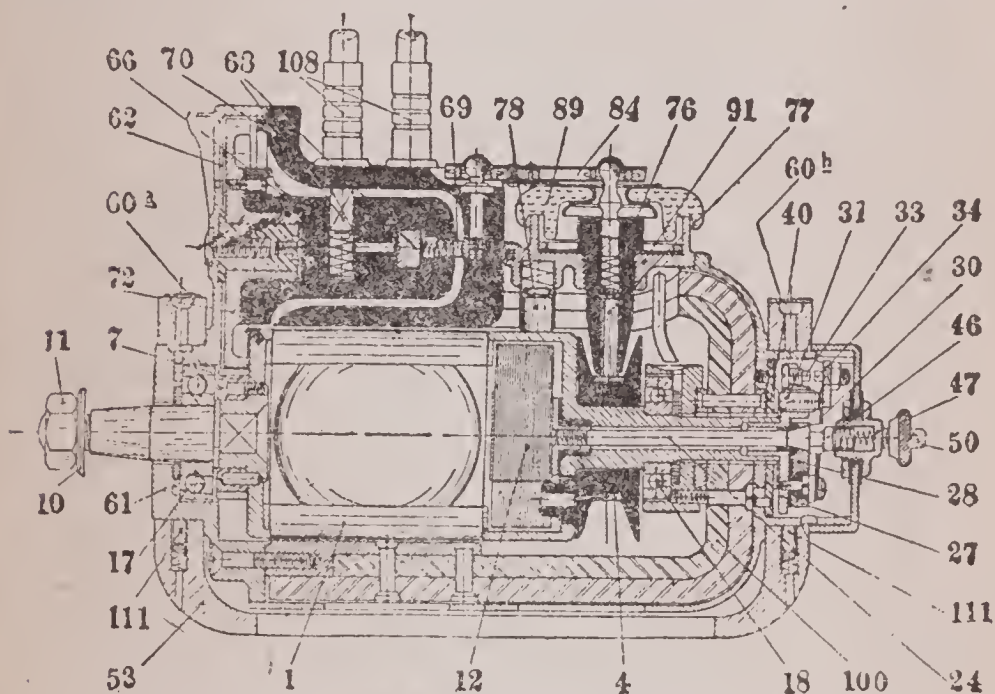


Fig. 68.—Cross-Section of BH Type Mea Magneto.

("Section through magnets in lower half of magnets is taken at right angle to rest in order to show pole piece construction.")

terminal of the distributor body and into the collecting carbon (69). This carbon is connected metallically with the distributing carbons (68), which, as they rotate inside of the distributor body, deliver the high-tension current to the brass segments and up into the cables, which in turn carry the current to the spark plugs. The internal electrode of the spark plugs is insulated and the current jumps from the point of this electrode to ground in the part of the spark plug which is in contact with the cylinders. This is the spark which ignites the gas.

Provision is made for grounding the spark in case there is a broken or improper connection to ground through the spark plugs. The spring leading from the terminal of the high tension carbon holder connects with a brass pin that is set in the center of a mushroom shaped piece of porcelain. This pin is entirely insulated from ground by only a small gap. When the electric pressure in the armature is raised above normal by a break in the natural course of the secondary current, the electricity will jump the gap above referred to and go to ground in the magneto housing. In this way the armature is saved from destruction in case of a broken connection to the spark plugs.

As it is necessary, in order to obtain the highest efficiency in a gas engine, to time the spark so that it will always occur when the piston is at the highest point of its stroke, magnetos have been so constructed that the breaking of the primary spark can be controlled within a certain range. This is accomplished by turning the cam which actuates the breaker forward or backward, so that the break will occur later or earlier, respectively. As it takes an appreciable amount of time for the gas in the cylinder to ignite, it is necessary to light the gas earlier as the speed of the motor increases.

There are also a number of other high-tension magnetos of the armature type. However, they have been omitted, owing to the limited space.

THE INDUCTOR TYPE MAGNETO.

The instruments described above were said to generate their current on the principle of placing the windings on the armature core. However, the inductor type differs from these in that the windings are stationary and the armature is replaced by inductors which revolve. The inductor type, like the armature type, con-

sists of horse-shoe shaped magnets and pole shoes, which form the magnetic field mounted upon a non-metallic base. The inductors are placed upon a shaft, which is termed the rotor shaft, while the inductors in some cases are fan-shaped.

The contact breaker or interrupter is also used to open and close the primary circuit at the

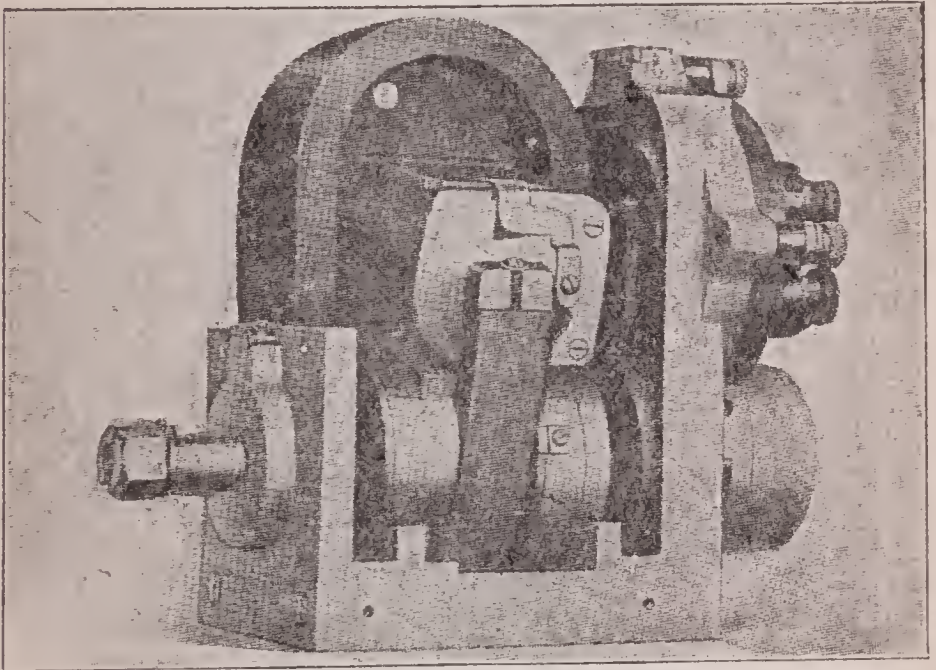


Fig. 69.—The Dixie Inductor Type High Tension Magneto.

proper time, while the distributor is also resorted to to distribute the high tension current to the proper cylinders. In fact, this type of instrument incorporates all of the principal parts mentioned in connection with the previous types, such as the condenser, safety spark gap and switch. The windings may be arranged for either high or low tension current and may either be placed in the magnetic field, at the rear of the magneto, or the secondary winding may be incorporated in a coil.

THE PITTSFIELD INDUCTOR TYPE MAGNETO.

The Pittsfield magneto employs the induction

method of generating current and may be classed as a high tension instrument. While the usual primary and secondary winding are utilized, they are not incorporated with the armature, but are at the rear of the instrument and stationary. This instrument also has four pole shoes instead of two. Two of these are attached to the permanent magnets in the usual manner. The others, with the iron core of the coil, comprise the magnetic field in which the inductor rotates on ball bearings.

One end of the primary winding of the transformer coil is connected to a contact button which is at the left of the horizontal bar above the interrupter mechanism. The other end of the primary is attached to a contact plate incorporated in the horizontal bar referred to, which is secured onto the field and insulated. A connection is made for the passage of current to the platinum contact piece and contact screw. This contact breaker or interrupter consists of a cam which separates the point twice during each revolution, through a lever bearing on a cam and carrying one of the points. The distributor is of conventional design and mounted above the inductor or rotor shaft.

The secondary winding is incorporated in a transformer coil mounted at the rear end of the magneto. One end of the secondary winding is connected with one end of the primary, while the other is attached to a metal bridge which connects with the safety spark gap. From this bridge the high tension current is conducted to the distributing brush, by conductors which are insulated.

THE DIXIE MAGNETO.

This is another instrument of the inductor type which has been introduced by the Splitdorf Co., especially for eight and twelve cylinder en-

gines, which, it is claimed, has solved the ignition problem of these V-type engines. This instrument also generates a high tension current without the use of an outside coil.

Its most radical departure from ordinary magneto practice consists in having the field magneto straddling the length of the revolving part, or rotor, so that the axis of this rotor lies in the central plane of the field magneto, instead of being perpendicular thereto as in the ordinary construction. No movable wires are used, as the windings are stationary, the current being induced by the rotary movement of the rotor, which consists of a central part of non-magnetic material with pole extensions of magnetic material on each end, the whole unit being supported on ball bearings.

The distributor is of the so-called compound type, as in the eight cylinder type there are two rows of four segments each and in the twelve cylinder type there are two rows of six segments each. These segments are arranged on cylindrical surface instead of a flat surface. Two radial contact brushes are carried by the revolving member of the distributor, each being adapted to make contact with one set of segments.

The contact points of the interrupter are opened by a cam mounted on the rotor shaft, as the contact points are stationary and may be adjusted while the instrument is running.

THE REMY MODEL "R-D" INDUCTOR TYPE MAGNETO.

This instrument was formerly made by the Remy Co., and while it is of the inductor type, it is designed to generate a low tension current, which is transformed to a high tension through a transformer coil. The accompanying illustration shows the rotor shaft which has fan-shaped

inductor wings, and the stationary winding located between the two inductor wings. This rotor shaft is mounted on ball bearings and the rear end carries the distributor driving gear and the contact breaker. The distributor is mounted

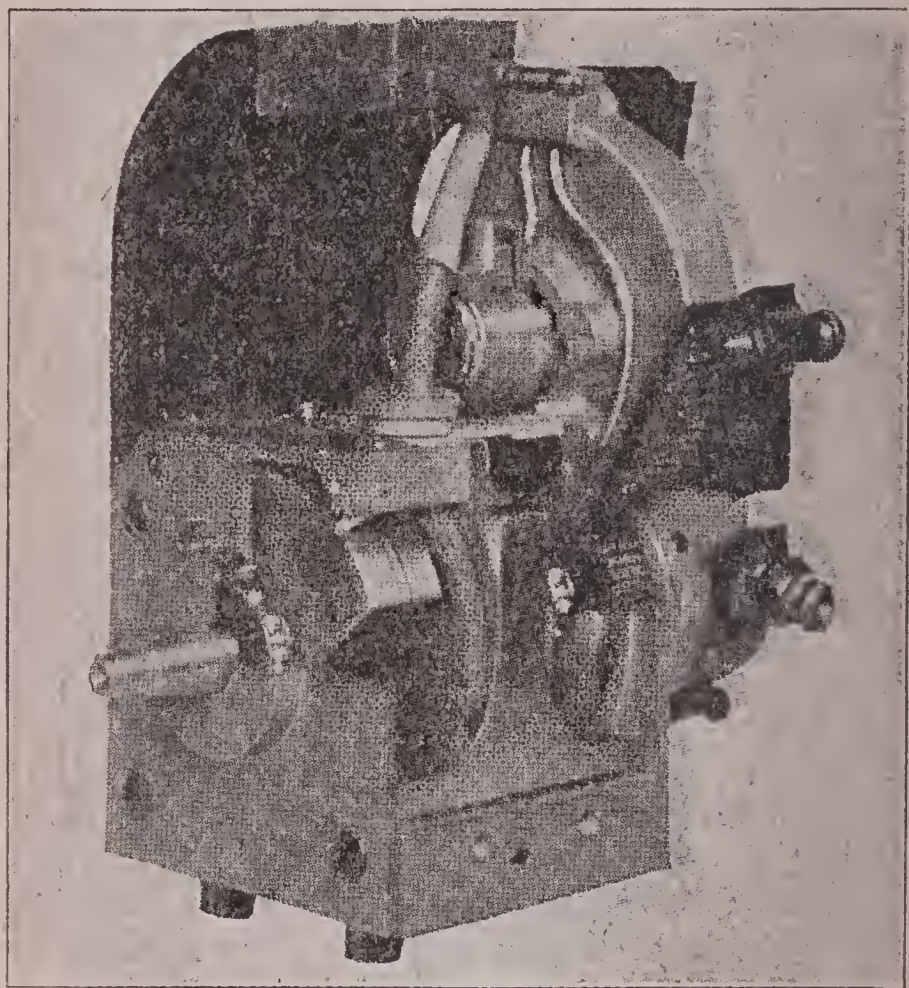


Fig. 70.—Cut-Away Section of the Remy Model "R D" Low Tension Inductor Type Magneto.

above the rotor shaft and is of conventional design. Various types of coils have been used with this instrument.

There are a number of magnetos of the three types mentioned above made in this country, but owing to the space required to describe each one it has been necessary to omit quite a few. However, the above descriptions serve to cover all types excepting details of design.

The Front Axle

THE front axle of a motor car is largely depended upon for safe control of the vehicle, since this must carry the forward portion of the load and must be arranged as to permit steering the front wheels. This is accomplished by pivoting the front wheel spindles and holding them in proper relation to each other by a tie rod. These spindles are pivoted from the axle proper and are generally termed steering knuckles. The spindle and its pivot are forged integral, while the levers for steering connections may also be forged integral or keyed in position.

VARIOUS TYPES.

Steering knuckles at present are of three different types, which are known as the Elliott, reversed Elliott and Lemoine types. American practice is divided, however. The first two are more extensively used than the latter. In the Elliott type the steering knuckle is T-shaped and the axle proper has two forked ends which fit over the knuckle. A long bolt, termed the king bolt, passes through both. In the reversed type the knuckle is forked and the axle ends have a T, while in the Lemoine type both axle end and knuckle form L's. In practice the construction of each type differs somewhat, depending somewhat upon the type of bearing and the method of mounting the knuckle in the axle end.

Owing to the importance of the knuckles and their levers, these are always forged from a good quality of steel and heat treated. Location of the tie rod depends upon the general arrangement and may either be placed in front or in the rear of the axle proper.

THE AXLE.

Material for the axle proper is generally forged from medium carbon steel, and may either be of solid rectangular or I-beam section. The latter section, however, is almost universally used. Some few manufacturers use tubular axles, with drop forged axle ends secured to them.

FRONT AXLE AND FRAME CONNECTIONS.

In conventional designs, the only attachment between the axle and the frame is the vehicle springs, which are of the cantilever, semi-elliptic, quarter-elliptic or full elliptic type. These springs are made up from a number of steel plates. The upper plate usually has an eye at each end which is connected to the frame, while the mass of leaves are clipped to the axle at approximately the center of the spring. This applies to the semi-elliptic type. However, in the full elliptic one-half is clipped to the axle and the other to the frame at approximately their centers. In the quarter-elliptic type, the forward end of the spring is fastened to the axle, while the rear end is fastened to the frame. These spring clips are of the box type and fit snugly over the spring leaves, which rest on a pad on the axle proper and the ends of the clips pass through holes in this pad and are retained by nuts.

I-BEAM AXLES WITH ELLIOTT TYPE KNUCKLES

Fig. 71 illustrates the 1915 Marmon Six axle, having a drop forged I-beam center with integral spring pads, the topmost surface of this pad being considerably below the center of the wheel. The knuckle is of the Elliott type and is drop forged with an integral spindle, "H," on which the wheel rotates. A large Timken bearing is mounted in

the upper end of the axle fork, which is adjustable, since it is mounted on the king bolt, "C," which in turn is retained by nut "B." The entire thrust load is carried by this bearing, as a spacer is used at the lower end, which holds the king bolt central. In order to properly mount the

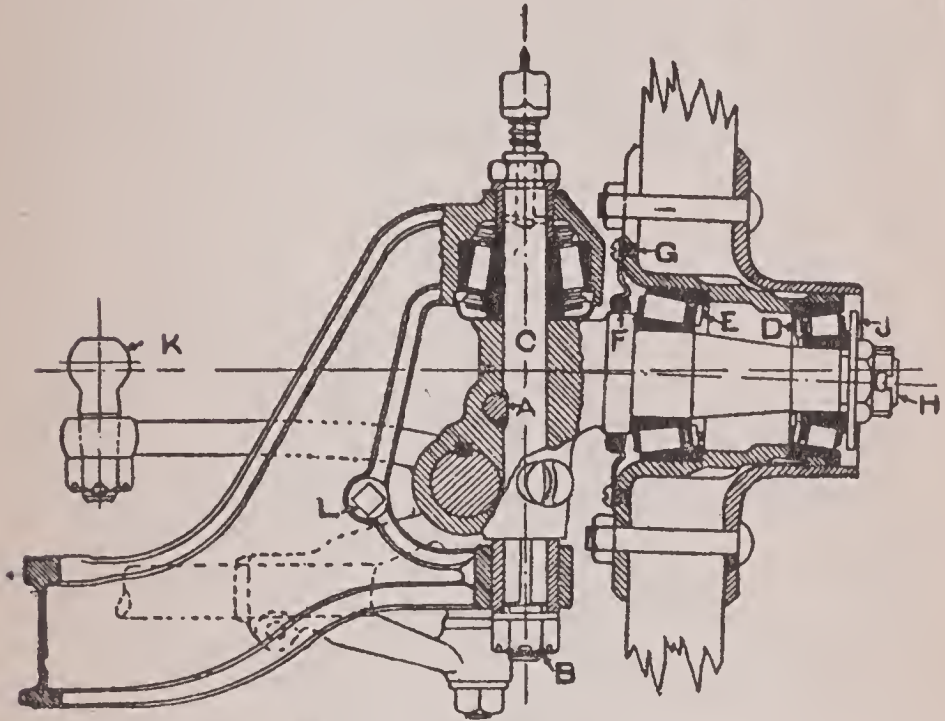


Fig. 71.—Marmon 41" Front Axle with Elliott Type Steering Knuckle.

bearing it is necessary to have the knuckles and king bolt work in unison. This is accomplished by the stud "A," which acts as a key. The drag link from the steering gear is connected to the ball "K," which is mounted in the knuckle lever. This lever has a projection to which the drag link is attached. The knuckle has a base near its lower end into which the lever is keyed and retained by a nut.

The wheels are mounted on Timken bearings "D" and "E" and are retained by a washer "J" and a nut. The hub cap, which is not shown, encloses the center bearing "D," while the inner one is enclosed by a steel stamping attached to

the hub by means of screws "G." In order to prevent grease from working out at this end and grit from entering, a felt washer "F" is placed in this stamping or shield.

Fig. 72 depicts the Reo axle, which has Elliott type knuckles and a drop forged center. The knuckle and spindle are also forged integral. However, they carry bronze bushings for supporting the king bolt, while a taper on the king bolt and a hardened steel washer take the thrust.

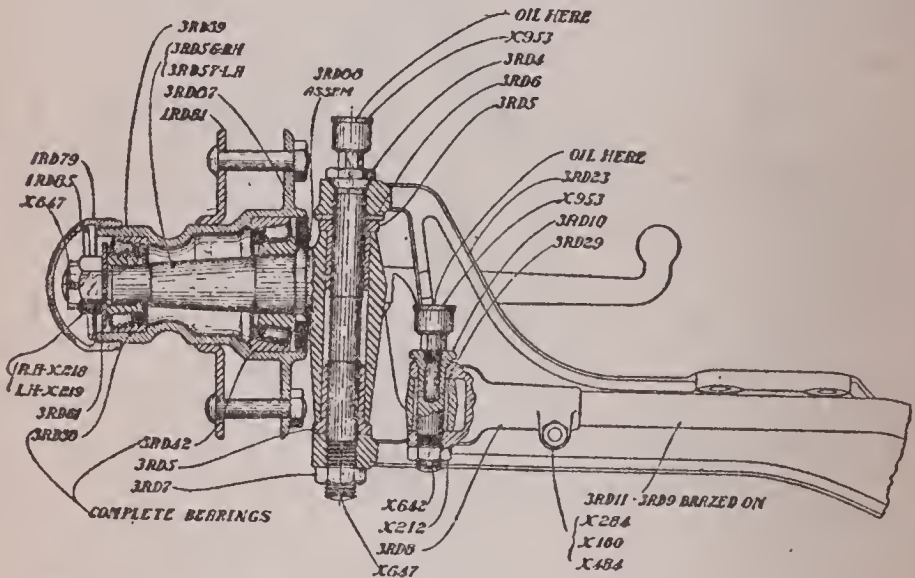


Fig. 72.—Reo Front Axle.

The wheels are mounted on roller bearings within a cast hub, while the hub flange is made of pressed steel. A ball is forged integral with the knuckle lever, while the general construction and mounting of the tie rod end and bolt is similar to the king bolt. Grease cups are provided in both so that the lubricant can be forced directly to the bearings.

THE REVERSED ELLIOTT TYPE.

Fig. 73 illustrates the reversed Elliott type of knuckle, which is quite popular on foreign cars and rapidly gaining favor in this country. The bearings are always placed in the knuckle fork and are provided with hardened steel bushings.

A ball thrust bearing may be fitted as shown. However, hardened steel thrust washers may also be used. Steering levers and the other details may be mounted as described above.

THE LEMOINE TYPE.

The Lemoine type of knuckle is shown in Fig. 74. The type was at one time very popular on French cars. However, it was abandoned as

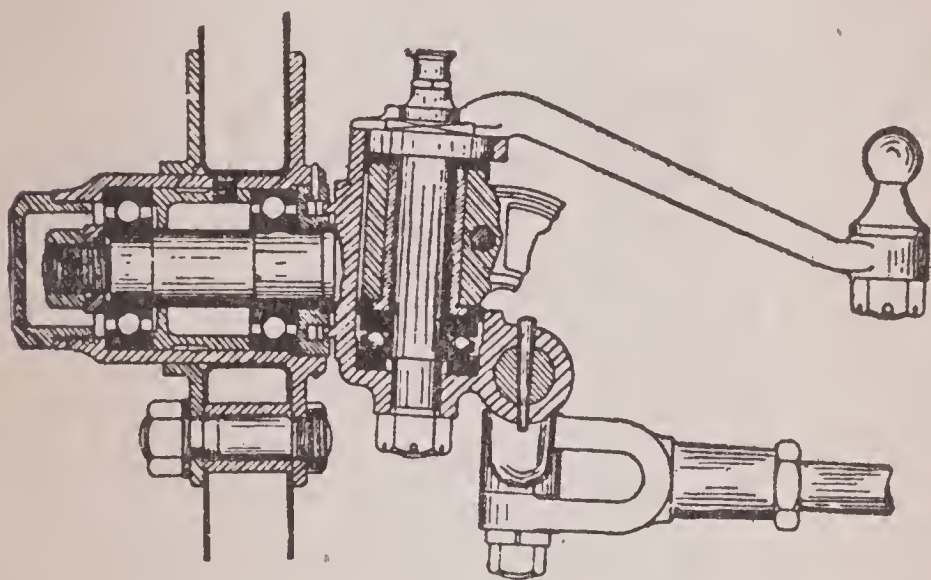


Fig. 73.—Reversed Elliott Type Knuckle.

the thrust load on the bearings is very large, even when the vehicle is at rest or running over a smooth road surface. This load is considerably increased by shocks on uneven pavement. The axle end in this case is formed into a nearly vertical hub of considerable length, and through this is a nearly vertical hole. The king bolt passes through the knuckle and the hub on the axle end and is secured by a nut in order to prevent the knuckle from dropping. A thrust bearing must be used between the axle and the knuckle, and so arranged that the entire load can be taken on it.

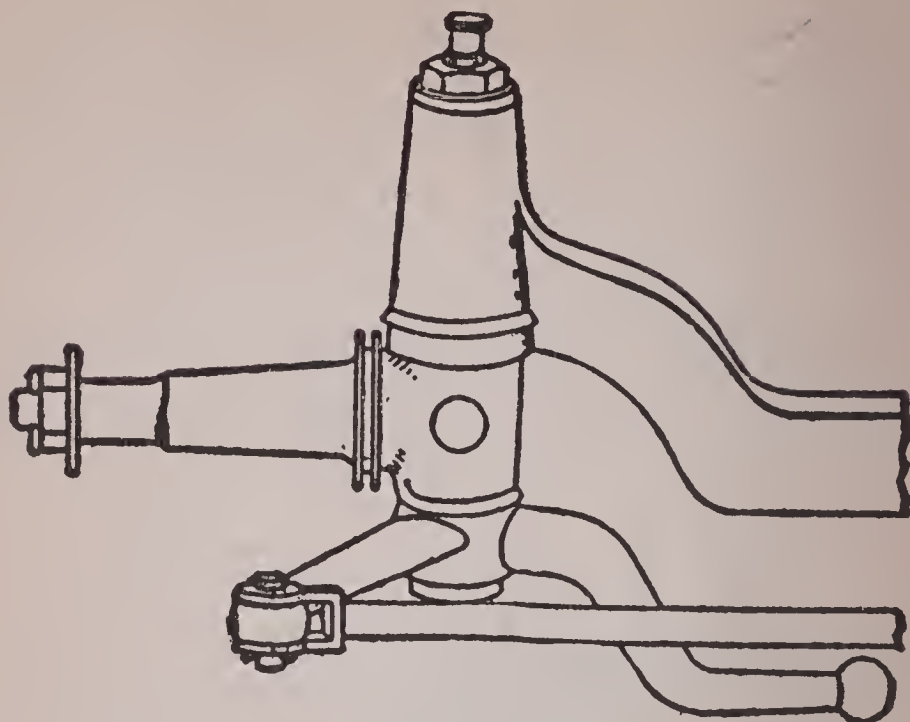


Fig. 74.—Lemoine Type Knuckle.

THE INVERTED LEMOINE TYPE.

A modification of the Lemoine type is shown in Fig. 75, which may be termed inverted Lemoine type. In this construction the axle also has a hub with a nearly vertical hole. However, the knuckle has the king bolt or pivot pin forged

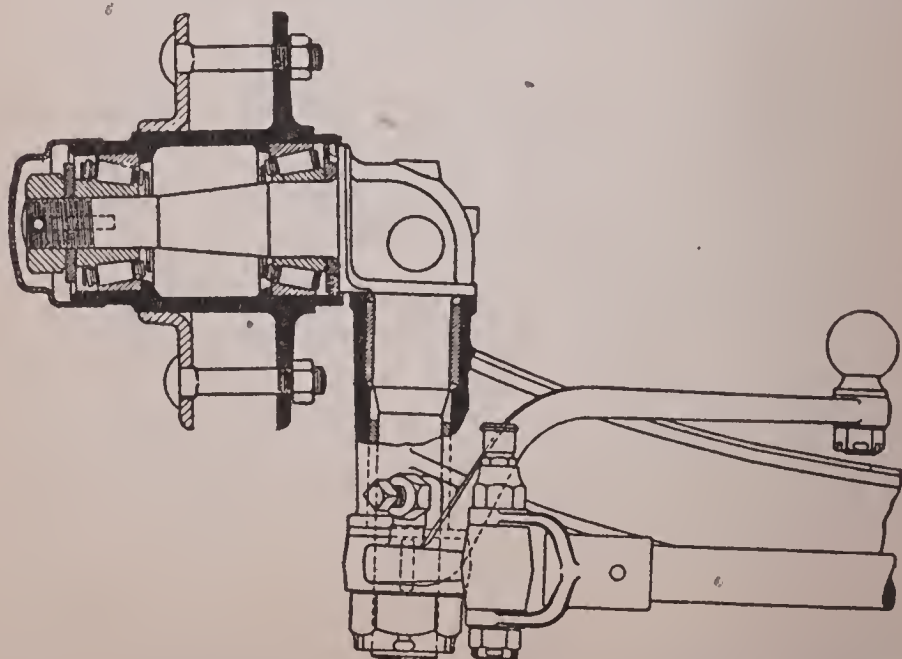


Fig. 75.—Overland Axle with Inverted Type Lemoine Knuckles.

integral, and the wheel spindle is located above the axle end instead of below. The wheels are mounted on taper roller bearings, while the knuckle is mounted on hardened steel washers and bushings. The steering levers are keyed directly to the end, the pivot and all are retained by a large castellated nut. This illustration represents the 1917 Overland front axle.

WHEEL BEARINGS.

All American motor cars are equipped with anti-friction bearings for wheel mounting, such as the ball and roller types, which are capable of carrying both a radial and thrust load. The mounting of these bearings presents no difficulty, and they are generally provided with adjustment for wear. These bearings must be thoroughly enclosed so that the hubs can be packed with grease and kept free from grit. Should the presence of grit be detected, the only thing to do is to wash the bearings thoroughly with gasoline and dry them, after which the lubricating must be done over again. It is good practice to examine the wheel bearings every 4,000 miles, or at least once a year, and while they are being examined they should be thoroughly cleaned. Cup grease should be used for lubricating them.

WHEEL ALIGNMENT.

An important factor which has an intimate relation to the mileage obtained from tires is the alignment of the wheels. This is especially true of the front wheels, which should be tested at regular intervals. This can readily be accomplished by measuring the distance between the inside of the rims at front and rear of axle. The same distance from the floor. They can easily be adjusted by the tie rod, which always has an adjustment for this purpose.

The steering knuckles are usually placed at a slight angle to make steering easier. This means that the front wheels should toe in about $\frac{1}{4}$ -inch, which is generally enough to correct the tendency of the front wheels to toe outward when the car is running.

WHEELS.

Wheels occasionally develop a squeak, which in the majority of cases is due to loose hubs. This can easily be remedied by tightening the hub bolts. However, should the squeak occur in the felloe or spokes, it is due to the wood drying out, as it may have been in a green state when cut. About the only remedy for this is to thoroughly soak them in water, which causes the wood to expand, thus tightening the joints. Wheels may also be tested for trueness by jacking up one at a time and placing a stationary point almost against the felloe band, then revolve the wheel to determine if the distance between the stationary point and the felloe is the same at all points on the circumference.

The Clutch

IT IS a rather difficult matter to compare the advantages and disadvantages of the automobile clutch, owing to the variety of types, however, the requirements of a good clutch may be itemized as follows:

It must possess ample holding power and reliability to transmit power given it. It shall be capable of a gently progressive engagement, without undue care on the part of the operator, and its engagement shall be prompt and complete.

Owing to the defects of motor car engines, relative to their flexibility, it is the inability to develop their full torque from a standstill. The crankshaft must rotate at speeds consistent with power requirements, while the road wheels necessarily must rotate consistent with road conditions, or at the will of the operator. This defect makes it necessary to use a transmission, which with its various speeds increases the motor torque. The engine is started by an electrical starting device, which produces just enough torque to spin the engine and overcome the resistance on the compression stroke. This, of course, means that it is necessary to disconnect the engine from the other driving units of the vehicle. When the engine has attained its speed it must be connected with the driving units of the vehicle again.

From the above it can readily be understood that the device used for this purpose must permit a certain amount of slippage until the motor speed has been reduced, and the speed of the vehicle gradually accelerated until the two correspond, thus preventing shock and jar to the driving mechanism.

The device used to accomplish these features is called the clutch, its location most generally being in close proximity to the motor, the most popular position being inside the engine flywheel; however, motor cars have been built in which the clutch was mounted in a separate compartment at the front end of the transmission. A single clutch is invariably employed to connect and disconnect the engine from the driving units through the different gear reductions. These clutches are nominally held in engagement by springs and are controlled by a foot pedal, which serves to release the friction members when it is necessary to disconnect.

There are quite a variety of clutches in use at present; however, they are all of the friction type, and are either cone or multiple disc types.

THE CONE CLUTCH.

The cone clutch consists of a conical-shaped member which engages with a female conical opening in the flywheel, and a spring to hold it in engagement. It may either be operated dry or in oil; however, for the former it must be faced with a material which will not char or burn during slippage. When operating in oil the surfaces are usually metal to metal. The direct type in which the male member travels from the flywheel in disengaging is universally used at present. The action of the members of a cone clutch is similar to a wedge movement. Constructions vary and in practice both aluminum and pressed steel male members are used. The friction material is either leather or some type of brake lining, such as raybestos, multibestos, non-burn, etc. The most usual method of mounting is on an extension of the crankshaft with a suitable bearing and a ball thrust bearing to take the thrust of the spring. In some cases cork

inserts are used to obtain a higher coefficient of friction, while small flat springs are placed under the facing to insure gradual engagement.

THE DISC OR PLATE CLUTCH.

The disc clutch consists of a number of discs or plates which present a multiplicity of small surfaces in preference to the two large surfaces of a cone clutch. The discs are divided into two sets, one being termed the driving discs and the other the driven discs. The driving set of discs are provided with key slots or holes on their outer circumference, which fit over hardened steel keys or studs fastened to a plate which carries the housing, or to the fly-wheel if the clutch is to operate dry. The driven discs are also provided with slots or holes, but these are placed on the inner circumference and fit over keys or studs attached to a hub or flange mounted on the transmission shaft. It is general practice to use one more driving discs than there are driven discs, so that the two end discs may be of the same kind. The driving set is driven by the engine, while the remaining set is attached to the transmission shaft.

When these clutches are intended to operate in oil they generally consist of a large number of plates, usually steel and bronze, forming a metal to metal contact. These clutches may also be operated dry, but the driven discs must be faced with a friction material as that used for cone clutches; however, the number of discs may be decreased. For this discs of both sets are usually made of saw-blade steel.

There is another type of disc clutch which operates dry and is sometimes called a plate clutch. In this type the plates or discs are made much larger in diameter and but three or five are used. The driving members are either faced

with friction material or of bronze and provided with cork inserts, while the driven members are made of steel.

THE CONE TYPE.

Fig. 76 illustrates the Marmon cone clutch, which is of the direct type. The cone or male member is made of aluminum, provided with a friction facing, and is bolted to a steel housing mounted on the extension of the crankshaft

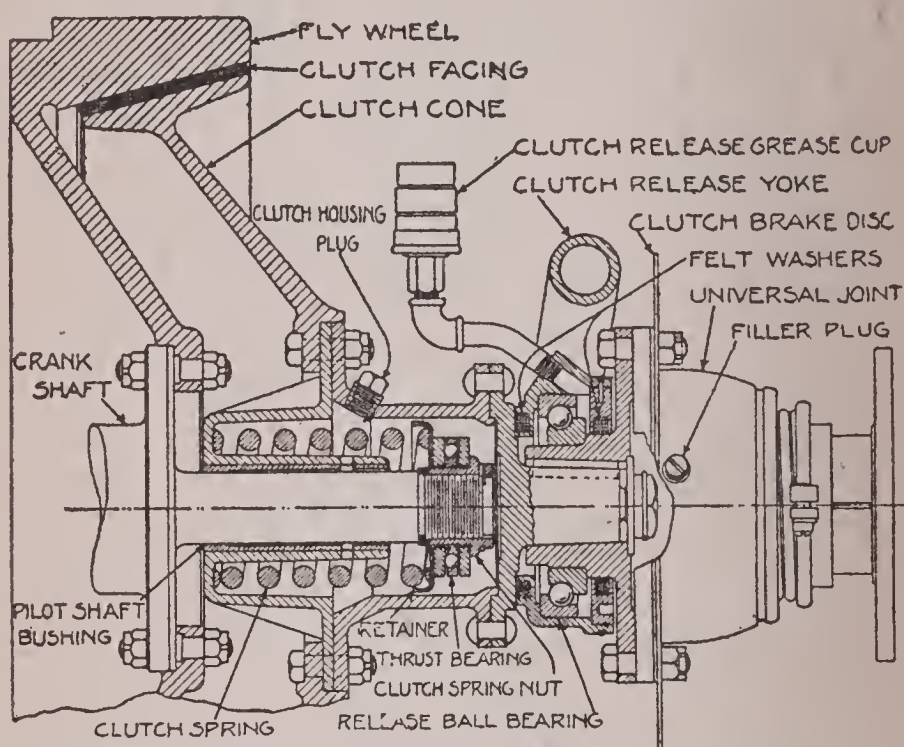


Fig. 76.—Marmon Cone Clutch with Aluminum Cone.

surrounding the clutch spring. This spring is provided with an adjustment and a thrust bearing which are enclosed in the housing. This housing carries an extension for mounting the hub of the universal joint and also a large ball thrust bearing to take the thrust in disengaging the clutch. Cone clutches are generally designed so that the spring thrust is self-contained. In this illustration one large spring is shown; however, in some cases several small springs are used.

These are generally fastened to a spider mounted in back of the cone.

THE MULTIPLE DISC TYPE.

A multiple disc clutch which has been extensively used in this country and abroad is the Helle-Shaw clutch shown in Fig. 77. The discs are made of steel and bronze, with V-groove corrugations. Only the walls of these grooves come in contact and the remaining portions of the discs serve to radiate the heat engendered during slippage. To permit the oil to enter and

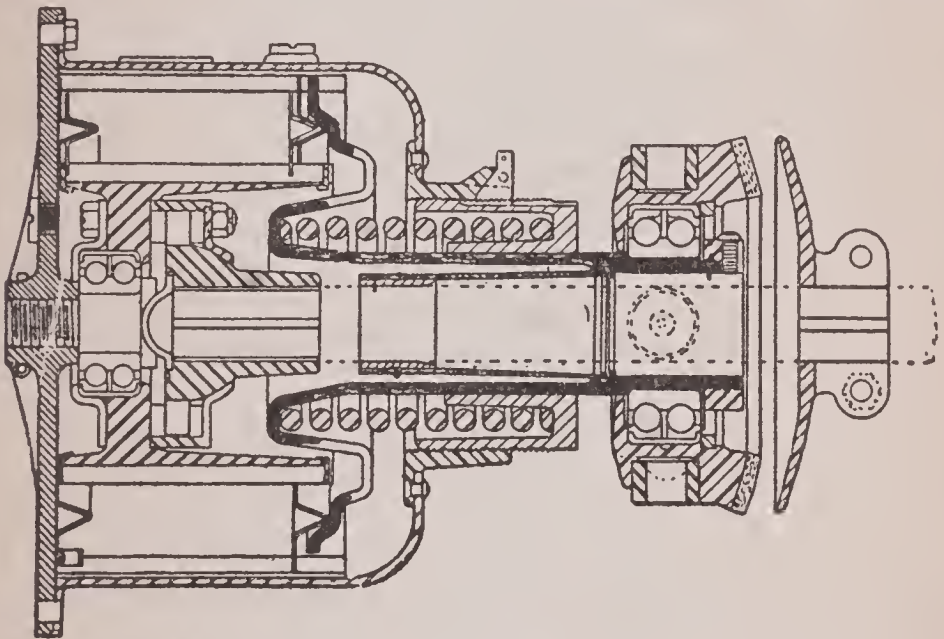


Fig. 77.—Helle-Shaw Multiple Disc Clutch, with Grooved Plates.

escape freely, these discs have small holes in the inner walls of the grooves near the peak. The action obtained by these grooves is a wedge action similar to the cone clutch. In this clutch pressed steel is used wherever possible to reduce weight. It is termed a universal type, as a universal joint is mounted inside of the clutch. An adjustable clutch brake is mounted upon the drive shaft. As oil is used, the plates must be enclosed, and this is the purpose of the pressed steel housing. The clutch is mounted by bolting it to the fly-wheel.

THE MULTIPLE DRY DISC TYPE.

Fig. 78 illustrates The Reo Six dry disc clutch, which is quite simple in construction. The driving member is cast integral with the fly wheel and has a number of gear teeth cut on its inner circumference which mesh with teeth cut in the driving plates. The driven member is supported

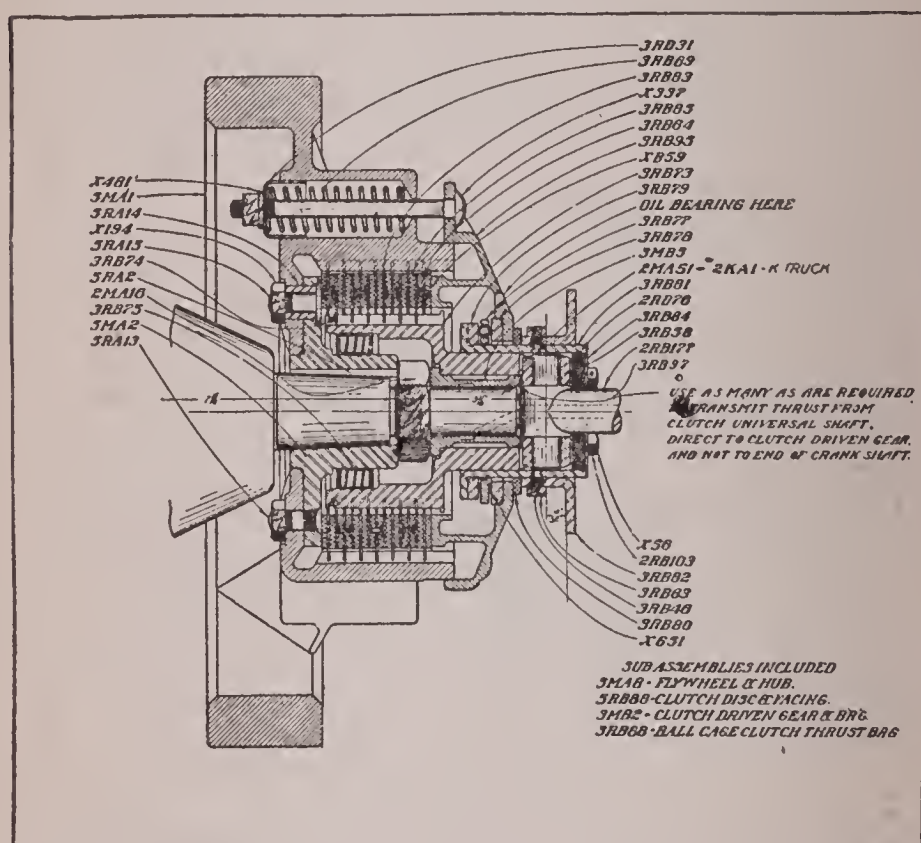


Fig. 78.—Reo Multiple Dry Disc Type Clutch.

by a Hyatt roller bearing mounted on a butt bolted to the fly wheel. This member has teeth cut on its outer circumference which mesh with teeth cut on the inner circumference of the driven plates. Both sides of the driving plates are faced with raybestos, and small springs, adjustable from the inner side of the flywheel, holds both sets of plates in position.

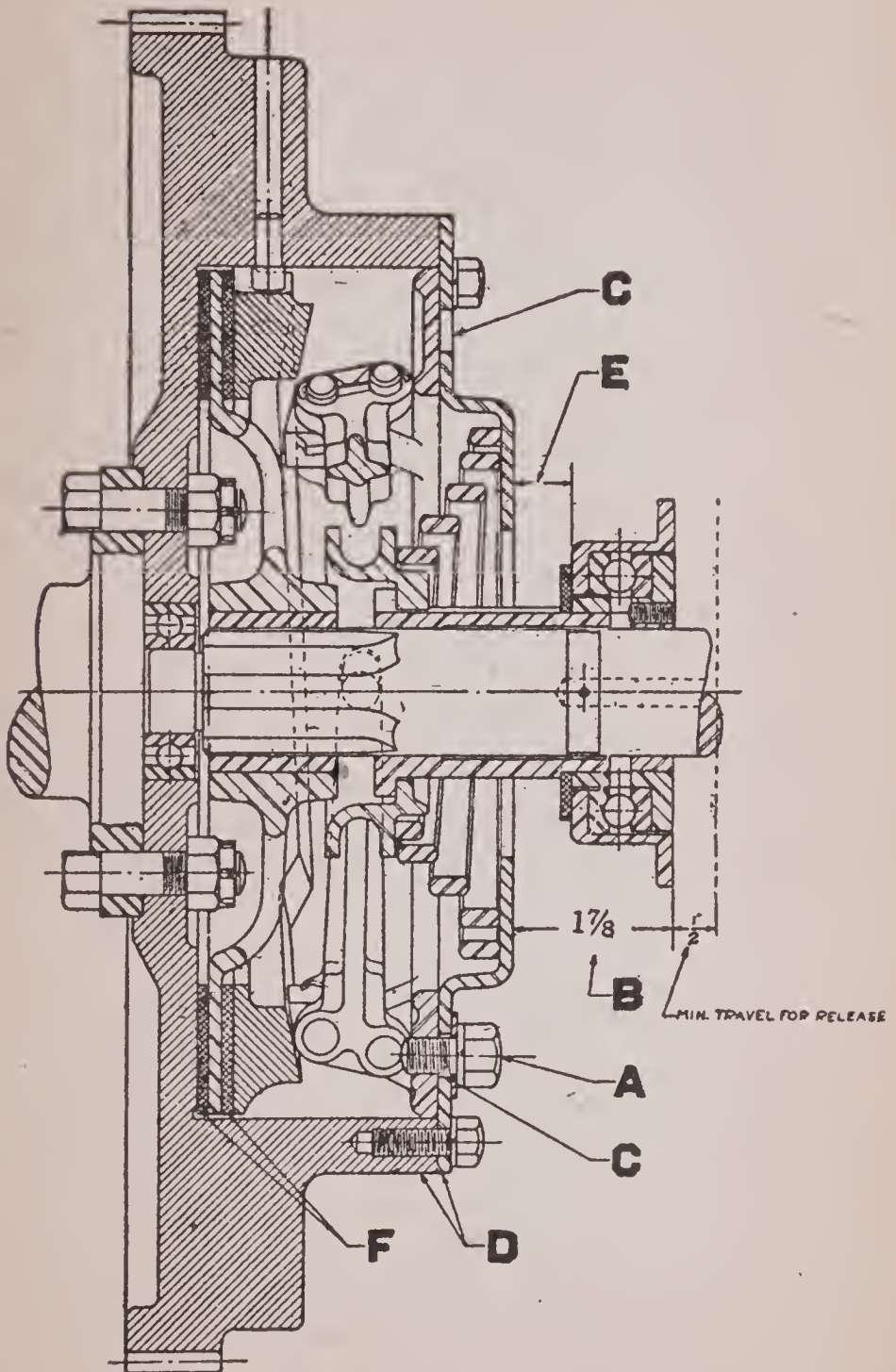


Fig. 79.—Borg & Beck Dry Plate Clutch.

THE DRY PLATE TYPE.

Fig. 79 illustrates the Borg & Beck dry plate clutch which is used on a number of vehicles of both passenger and commercial types. This consists of a driven member keyed to the transmission shaft and two raybestos discs which bear against the fly wheel and the driving member keyed to the fly wheel, the driven member being located between the two raybestos discs, "F." A large spiral coiled spring, bearing against the housing cover and the disengaging collar, supports the toggle disengaging members connected with the driving plate. This housing "D" has two slots "C" which carry screws "A" attached to the toggle mechanism, which form an adjustment for wear.

THE CLUTCH BRAKE.

All clutches possess a certain inertia when they are disengaged, and this inertia causes spinning and makes gear shifting somewhat difficult. For this purpose a clutch brake is used which overcomes the spinning effect.

CARE OF THE CLUTCH.

A clutch should always be engaged slowly and carefully to prevent a sudden jar to the entire mechanism. Slipping the clutch should be avoided, and if slippage is noted it should be corrected. More harm can be caused by slipping in one trip than would occur if used with discretion one season. Parts requiring lubrication should be kept well supplied.

Electric Starters

THE gasoline automobile engine is an amazing example of engineering ingenuity, furnishing power at a less weight than any other form of engine, but it is peculiar in that it cannot start itself. This is because its cycle of operations includes only one stroke in which power is delivered to those in which it actually requires energy. Once it is running, the energy for those three waste strokes is supplied by the spinning fly-wheel; but to start it this energy must be furnished by some outside means. Hence the necessity of providing a starting crank, or the more popular equivalent, the starting motor.

The electric starting system is now universally used and usually is combined with an electric lighting system. Since some source of current supply and storage must be used, it is necessary to provide a generator and a battery. These three component parts make a complete electrical equipment. For the convenient distribution and control of the current, such units as switches, ammeters, connectors, wiring, etc., are also included. The motor and generator may either be arranged in separate units or combined in one unit. Both types are quite popular and have peculiar advantages of their own.

THE GENERATOR.

The generator is incorporated for the purpose of producing current. These generators are of two types, the permanent and excited or wound field types. The voltage of electric systems varies considerably; however, the six and twelve-volt systems are leading types now being used.

This generator is always mechanically driven from the engine, either by direct drive or through a belt or chain, depending on the generator speed and the chassis design in general.

THE STORAGE BATTERY.

All current produced by the generator and not consumed by the lamps or other electrical units passes through the storage battery and held in reserve for starting or lighting when the car is at a standstill, or for lighting and ignition when the car is being run at very low speeds.

These batteries are of special design to give maximum efficiency and working life under the severe conditions of motor car operation. The mounting of this unit is generally determined by the conditions of appearance and accessibility, three positions being available—under the body, seats, or running-boards. When mounted on the running-board it is usually set into a steel battery box for mechanical protection and appearance.

THE STARTING MOTOR.

The motor, which takes the place of the more common hand-crank, is operated by electric current from the battery, and in revolving it cranks the engine, the power being applied by individual methods in different systems.

CONTROLS.

Automatic operation of the three units mentioned above requires several mechanical and electrical controls, which are termed the circuit breaker, the governor, and switches.

The circuit must positively and automatically open the circuit between the generator and battery when the car is standing or running slowly, so that the battery cannot discharge current back through the generator. This circuit breaker is usually operated by an electro-magnet and may

either be built into the generator or in a separate unit.

The governors are designed to automatically prevent an excess output of the generator, and they may either operate mechanically or electrically. The mechanical governor is a friction-driven mechanism mounted on the generator shaft and automatically limits the speed of the generator to a fixed number of revolutions per minute. The maximum output of the generator is in this way held to a certain predetermined amount, independent of the speed of the engine or car. The purpose being to prevent the possibility of overcharging the battery or overheating the generator. The electrical governor has nothing to do with the speed of the generator, but controls its output by means of armature reaction and a reversed series field winding.

THE AMMETER.

Some means must be provided for indicating at all times the amount of current being produced by the generator or discharged from the battery. This instrument is usually mounted in plain view of the operator on the cowl or dash and is called the ammeter.

SWITCHES.

The lighting switch is also mounted on the cowl or dash within convenient reach of the driver. It is made up of a number of units so that the head, side and tail lamps may be controlled independently of each other.

The purpose of the starting switch is to complete the circuit between the starting motor and the battery when it is necessary to start the engine. It is generally arranged to be operated with the foot and may either be installed on the foot-board or near the starting pinion.

WIRING.

The wiring for either starting or lighting are independent of each other and are easily recognized, as the starting wire is always of single, heavy, round conductor cable, while the lighting wire is of much smaller twin conductor cable or single strand cable.

There are a variety of systems in use at present; however, several will be illustrated to assist in describing the general construction.

Fig. 80 illustrates the Autolite starter and its mounting on the Chevrolet cars. A small pinion

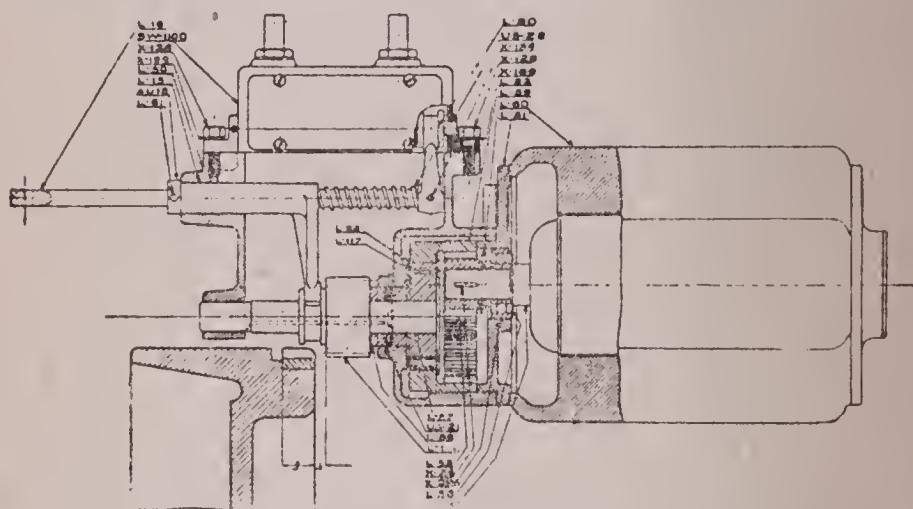


Fig. 80.—Cross Section of Auto-Lite Starter on Chevrolet Six.

is mounted on the armature shaft of the starting motor, which meshes with an internal gear mounted within a housing attached to the starting motor. This gear is mounted on a shaft which carries the governor over-running clutch and also a pinion which may be slid into mesh with a gear mounted on the fly-wheel. This sliding pinion is shifted by means of a fork and shaft connected with a foot pedal. The shifting shaft is also connected with the starting shaft so that the pinion can be meshed with the fly-wheel and the circuit completed between the starting motor and the battery.

RUSHMORE STARTING AND LIGHTING SYSTEM.

The Rushmore Engine Starter and Dynamo are distinguished by extreme simplicity of mechanism, and action so completely automatic that none of the usual manipulations are needed either in starting the engine or in regulating the charge delivered at the battery.

The Starter acts directly on the flywheel, the usual intermediate gears being omitted. A pinion

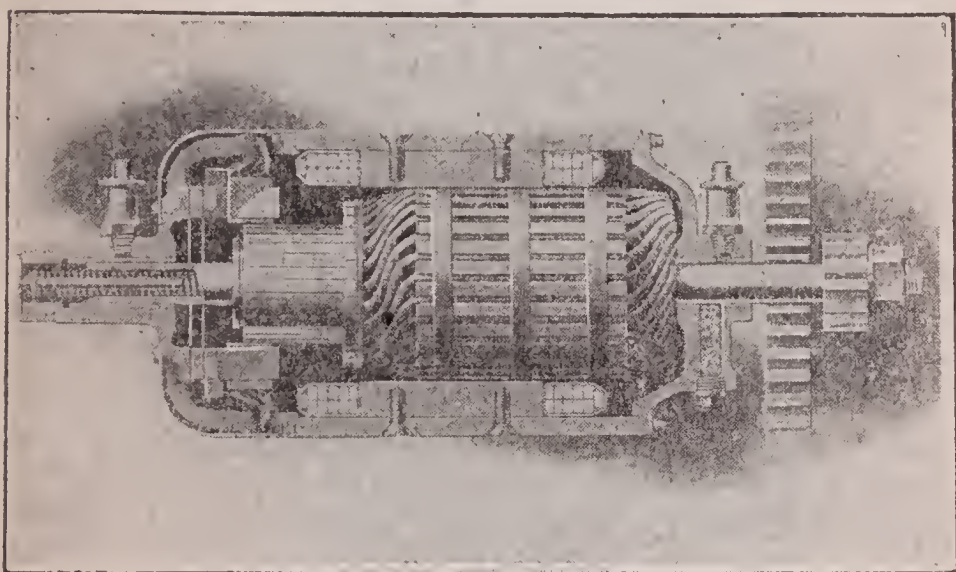


Fig. 81.—Rushmore Starter.

on the armature slips automatically into mesh with the flywheel gear when the button is pressed, turns the engine over at a rate of 75 to 300 r. p. m., and slips automatically out of mesh again as soon as the engine picks up. The operator has nothing whatever to do with the performance after the button is pressed.

The illustration shows the starting motor in section with the armature out of action. The pinion at the right-hand end of the shaft is keyed fast, and the whole armature moves bodily end-wise with its shaft to engage and disengage the pinion. The left-hand end of the shaft is hollow and carries a compression spring by which the

armature is held out of action in the position shown. In this position the armature is out of line with the pole pieces of the field magnet.

When the starting switch is closed the attraction of the pole pieces draws the armature strongly to the left, thus meshing the pinion and causing the armature to turn.

With the first explosion the armature is relieved of its load and the current which it draws from the battery drops instantly almost to nothing, so that the attraction of the pole pieces is not sufficient to hold the armature in its working position. The spring, therefore, instantly pushes the armature to the right, thus slipping the pinion out of mesh before one can notice any increase in speed.

To insure the pinion meshing properly when the switch is closed the switch has two active contacts. The first contact practically short-circuits the armature and puts the field coil in series with a resistance. The effect is that the first contact gives the armature only enough turning motion to make sure that the pinion goes into mesh. The second contact cuts out the resistance and puts the armature in circuit so that it starts to turn the engine.

The Rushmore Dynamo is distinguished by having no mechanical current regulator. The output is governed by utilizing a peculiar property of iron wire, namely, that of increasing greatly in resistance at a critical temperature a little below red heat. The manner in which this property is utilized is simple and highly ingenious. The dynamo field magnet is wound with the usual shunt coil, and in addition with a "bucking coil" which is in series with the external circuit, so that the current delivered at the battery and lamps goes through the bucking coil. The effect of the bucking coil is to reduce the excitation of the field magnet. This reduction in strength is, however, desired

only at low speeds, and here is where the iron "ballast coil," as it is called, comes in. This ballast coil, consisting of a simple strand of stove-pipe wire 10 inches long, is arranged as a shunt across the terminals of the bucking coil, so that the current delivered, instead of passing wholly

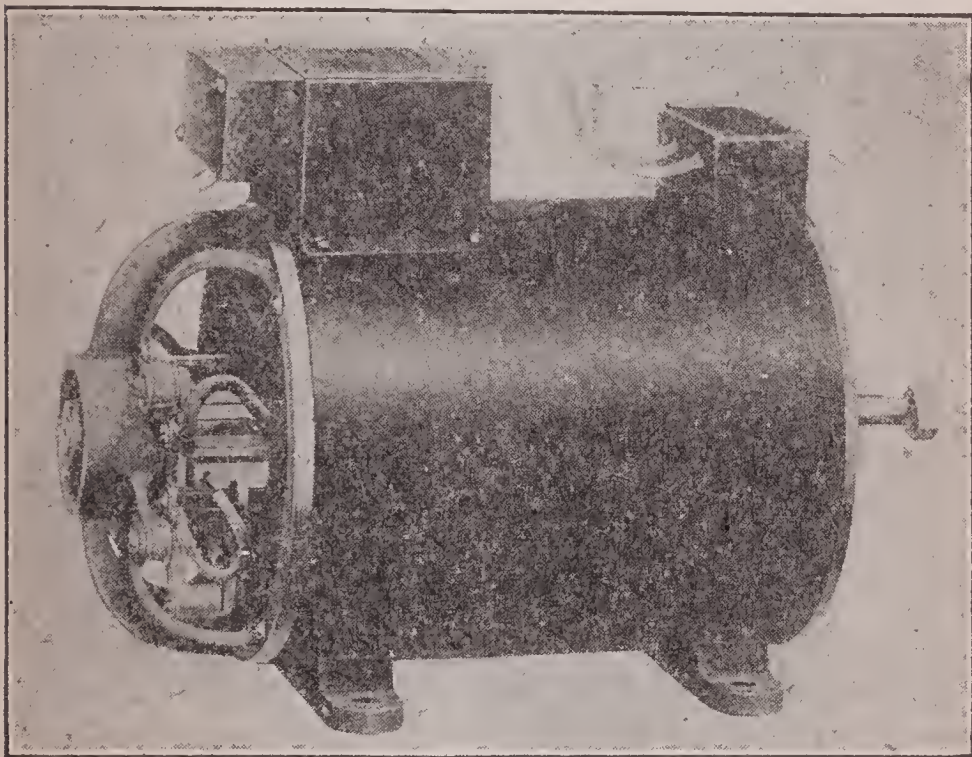


Fig. 82.—No B Dynamo with Cover C Removed of Busher.

through the bucking coil, divides between the bucking coil and the iron ballast coil on its way to the battery and lamps. When the ballast coil is cold it practically short circuits the bucking coil so that the latter has very little effect. As the speed of the dynamo increases its output increases also very rapidly, up to the point where the ballast coil becomes hot. When the delivery exceeds about 12 amperes the resistance of the ballast coil increases so much that a considerable portion of the current is forced to find a path through the bucking coil, thereby reducing the excitation of the field magnets.

A switch connected to the headlight switch cuts the ballast coil out of circuit, so that all the current from the dynamo has to go through the bucking coil; this reduces the output to about three amperes average when the headlights are out of use. This small current suffices for the demands of the small lamps, horn, ignition system, etc. Owing to the normal output being so large, the battery is not drawn upon at all when the lamps are lighted, unless the speed drops below about 15 miles per hour. Consequently the usual daylight recharging is unnecessary, and danger of the battery being unexpectedly exhausted by excessive night driving is eliminated.

CUT-OUT.

An automatic cut-out operated electrically, performs the function of connecting and disconnecting the generator and battery when the proper speed of the generator is reached. This connection is established when the engine has reached the speed that would propel a car on high gear at about eight miles per hour. It is then that the generator begins charging the battery, the rate of charge increasing until the car reaches approximately fifteen miles per hour, at which point the governor on the generator becomes operative and maintains constant armature speed. This means that the charging rate is constant regardless of the variations of engine speed above that required to propel the car fifteen miles per hour, and the commutator winding and brushes are not subject to excessive friction or speed. When the speed is reduced below fifteen miles per hour, the governor becomes inoperative as the machine slows down and as the car reaches the speed of approximately six miles per hour, the voltage of the generator is reduced to a point less than that of the battery, which permits a slight reversal of the flow of the current through the cut-out heavy winding.

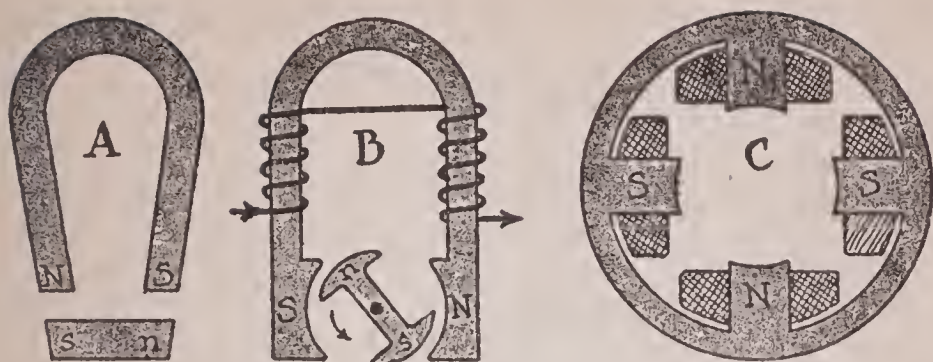


Fig. 83.—Evolution of the Electric Motor.

Inasmuch as there is still a low voltage current flowing from the generator through the fine winding on the cut-out coil, the effect of the reversal of the battery current is to cause a partial neutralization, thus reducing the strength of the magneto field which holds, by means of a movable armature, the contact points on the cut-out together. When this neutral point is reached a spring forces the two points apart, thus disconnecting the battery from the generator and preventing any waste of current. As this action is instantaneous, there is positively no way in which the battery current can run back through the generator. This is a very important feature and should not be underestimated. As a further matter of protection, the cut-out armature is housed, so that it cannot be cut in accidentally.

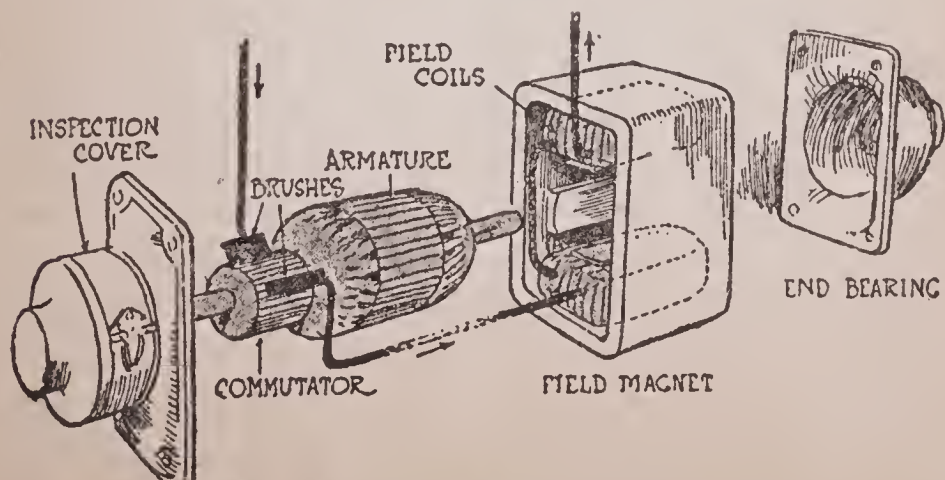


Fig. 84.—Starting Motor Disassembled.

The Universal Joint

UNIVERSAL joints serve the purpose of connecting shafts or control rods whose axis lie in the same plane but make an angle with each other. This condition applies to the drive shaft; however, a still greater difficulty exists, as the angle continually varies in practice.

In a chain-driven vehicle the motor and transmission usually remain in alignment when the vehicle is standing still; however, road vibrations and irregular loading cause frame deflexions which tend to destroy the alignment. In this case it is only necessary to have a universal which operates at a small angle. Now, in a shaft-driven vehicle the road wheels are continually bouncing over the rough surface of the road, while the movement of the frame at the front which supports the power plant is limited by the chassis springs. Thus, at one moment the axle is directly in line with the power plant, and the next moment it may be several inches above or below the motor center. The universal joint practically makes a flexible member to compensate for all these irregularities.

Engineers seem to differ as to the number of universal joints that are necessary in a shaft-driven vehicle. In some cases but one is used, while in others two are used. When the propeller shaft is enclosed in a torque tube but one joint is used; however, when an open drive is employed it must be provided with two universal joints.

In any type of shaft drive, regardless of propeller shaft or torque tube construction, one

universal must have what is termed a slip joint. In a chain-driven vehicle this slip movement is usually provided to compensate for the clutch movement in clutch disengaging and for variations in shaft lengths. It is also of considerable advantage in assembling the chassis.

This slip joint is necessary in shaft-driven vehicles, since some provision must be made to compensate for variations in the distance between the transmission and the rear axle housing due to the play of the springs.

Drive shafts are generally made of solid section; however with the increasing tendency toward the use of unit power plants arises the question of using hollow shafts, as with this construction the shaft length is increased considerably, and in order to overcome the whipping effect, its weight must be reduced as well as the pressure on the bearings.

The present tendency in motor truck design is toward shaft drive and a long wheelbase, which calls for a shaft of considerable length, so that it is necessary to reduce the whipping effect to a minimum. However, this is impossible even with very tight wall tubing of large diameter. This has resulted in the introduction of three universals and two shafts; one being attached to the transmission supporting one end of a shaft, while the other end of the latter is supported by a bearing from a frame cross-member. From this point the drive is through two universal joints and a shaft in the usual manner.

SQUARE BLOCK TYPE.

The simplest type of universal joint consists of square blocks secured to or forged integral with the ends of the shafts to be connected, fitting in a square hole in a sleeve secured to the driving and driven units. The four faces of

these blocks are curved in the direction of the axis of the shaft. This type of joint, owing to its limited angular movement is only used on chain-driven vehicles between the clutch and transmission. This construction is shown in Fig. 1, in which the square blocks are forged integral with the drive shaft. One sleeve is bolted to the clutch which forms the driving unit, while the other is bolted to the transmission or driven unit. This type also constitutes a slip joint, and springs are used to hold the shaft central. Leather boots are provided to enclose the surfaces and act as a retainer for grease. It can readily be understood that owing to the curvature of the faces of the blocks, one of the units can

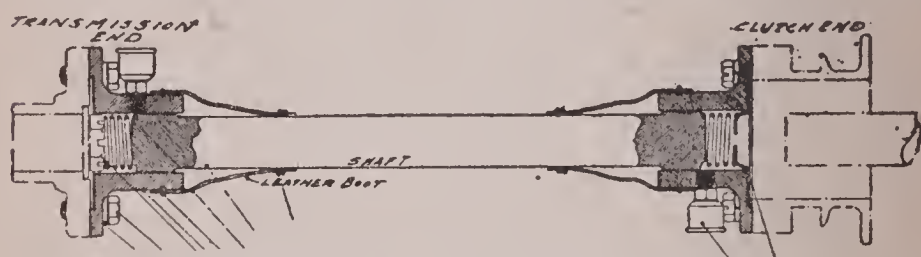


Fig. 85.—Square Block Type of Universal.

be moved angularly with relation to the other in two planes at right angles to each other. This type of joint may also be used on pleasure vehicles where the transmission is mounted amidships. With the unit power plant perfect alignment is always maintained and universals are not necessary between the motor and transmission.

THE FRICTIONLESS UNIVERSAL JOINT.

The frictionless universal (Fig. 86) is gaining favor for use between motor and transmission when these are mounted separately. This consists of two forks placed at right angles to each other, which are connected by a fabric disc. This type of joint is limited to operation at angles.

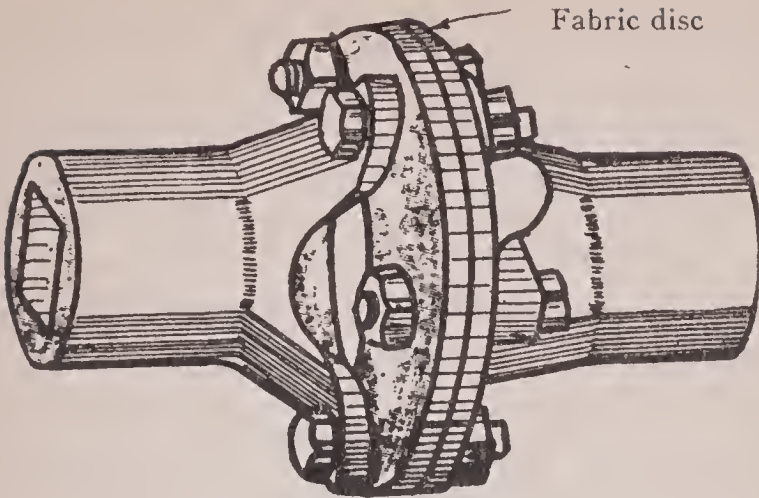


Fig. 86.—Universal Joint.

The modern universal joints used for connecting shafts, where their angle varies greatly, are sometimes called Hooke or Cordan joints. Present types are modifications of these and at present these are made by manufacturers who devote their entire production to this article. In a work of this kind it is impossible to illustrate every make; however, the principal ones are illustrated.

THE SPICER UNIVERSAL.

The Spicer is illustrated in Fig. 87, which is an

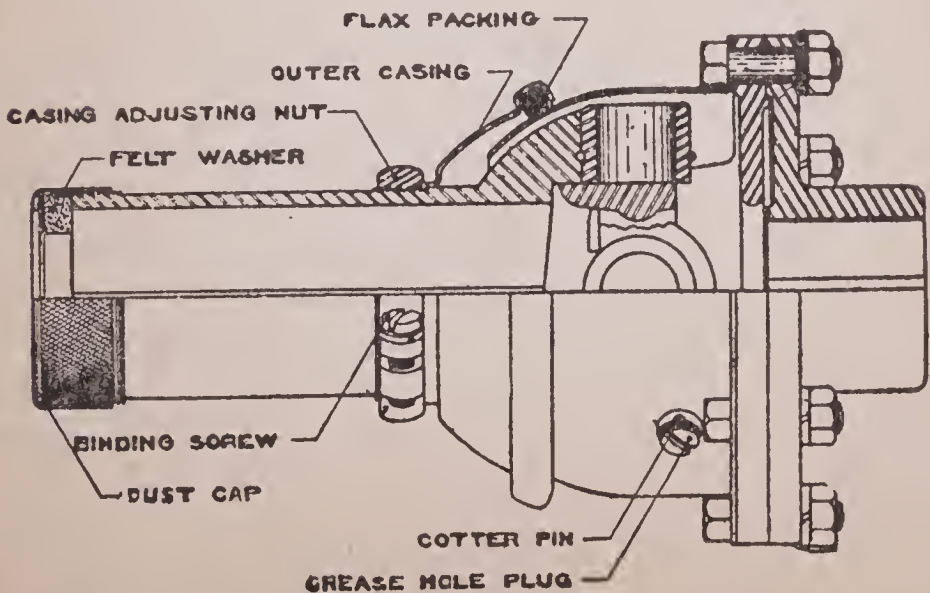


Fig. 87.—Spicer Universal Joint, showing Slip Joint.

excellent example of a modified Cordan joint. This comprises a central ring with pins forged integral, having their axles in the same plane. One forked end is integral with a hub which bolts to the hub of either driving or driven shaft end, while the fork may either have a short hub for permanent attachment or a long one for slip movement, the slip end being shown. The bearing ends of the forks have an opening large enough to permit inserting the pins, while they are also bored out large enough to take bushings which hold the ring and its pins in position. These bushings and forks have a circular groove cut into them, so that a soft wire can be inserted to hold the bushings in position. The entire joint is enclosed in a dust-proof pressed steel housing which also acts as a retainer for lubricant.

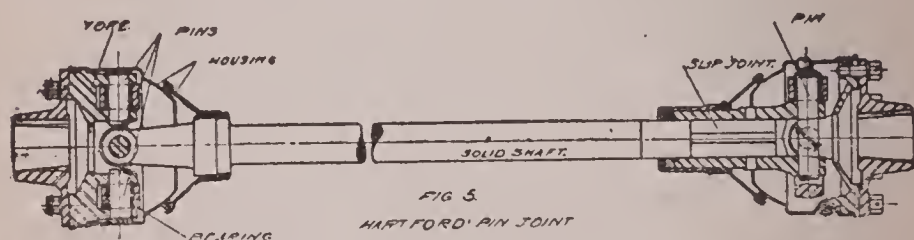


Fig. 88.—Hartford Universal Joint.

THE HARTFORD UNIVERSAL.

This joint (Fig. 88) differs somewhat from the Spicer in detail. Instead of the central ring being provided with four pins it is arranged with four bosses equally spaced, which carry hardened steel bushings. Two of these bosses fit into a fork which is formed integral with a hub, while the other two fit into the forked end of the shaft at one end, while on the other they fit over flat surfaces on the slip joint hub. These rings are retained by one long and two short pins as shown. Washers and cotter pins hold the long ones in position, and the shorter ones

resemble clevis pins and are also retained by cotter pins. The joint proper is enclosed and the pins have slots so that the lubricant can reach the bearings.

THE BLOOD UNIVERSAL.

This is also of the pin type, but differs in the method of inserting the pins. The center ring is replaced by a steel cube which enters the fork ends. The cube together with the pins forms a cross. One pin has an enlarged surface which fits into the cube, while the other is of one diameter and passes through the former and the cube. A small pin is inserted to lock both of these in

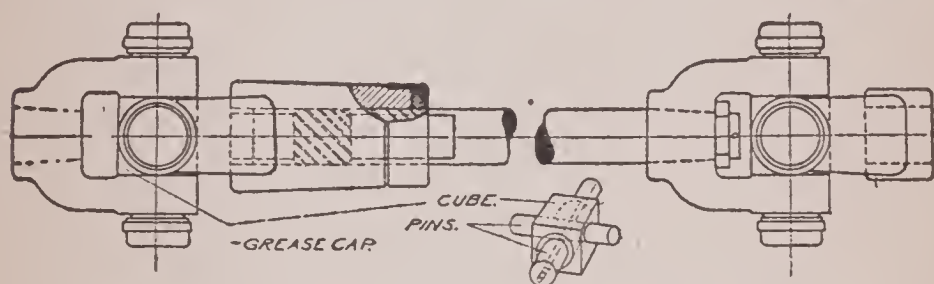


Fig. 89.—Blood Universal Joints and Shafts.

position. Each fork has hardened steel bushings which extend far enough to receive a grease cup, as shown in Fig. 89.

THE BLOCK AND TRUNNION TYPE.

Fig. 90 depicts this type of joint, which consists of a cup-shaped steel forging secured to one of the shafts, with two diametrically opposite longitudinal slots milled into its shell. The other shaft is provided with a ball-shaped end, fitting the interior of the shell and provided with pins or studs extending into the slots. Hardened steel trunnion blocks are interposed between the pins and the walls of the slots to distribute the bearing pressure. This type of joint, it will be noted, serves also as a slip joint. It can readily be enclosed by leather boots and represents a type

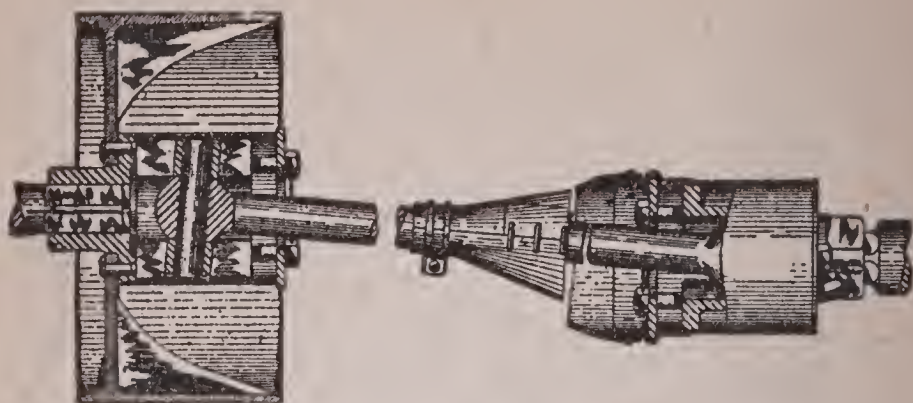


Fig. 90.—Block and Trunnion Type of Universal.

which has been extensively used. An entirely different type is shown in Fig. 91. On this the usual center ring is replaced by a spiral-shaped center piece having two internal and two external radial slots. The permanent yoke has two radial projecting surfaces, which fit into the external slots, while the pivoting member has two projecting surfaces which fit into the internal slots. The internal and external slots in the center piece alternate so that a spiral movement is obtained in any direction. A steel housing fits snugly over the external member and has a spiral bearing, while a cover is attached to it which retains the entire mechanism.

For some time these universals were not enclosed, and it was found difficult to lubricate them effectively. Centrifugal force would cause them to throw off oil and grit would work into the bearings. However, this difficulty has entirely been overcome by enclosing the universals in a dust-proof housing.



Fig. 91.

The Motor Cooling System

IT is the general impression that the office of the cooling system is to abstract the heat from the gases within the cylinders, this heat having been generated by the explosion. This impression is an erroneous one, for, as a matter of fact, the duty of the cooling medium is to keep the cylinder walls cool, the heat of the gases being converted into useful energy. These cylinder walls must be kept cool for two reasons. One is to permit of proper lubrication, without which the piston could not travel up and down in the cylinder. Lubricating oils have a definite flash point, and when this temperature is reached they will burn and leave a carbon residue. Thus it can readily be understood that the cylinder walls must be kept cool to prevent the carbonizing of the lubricating oil.

The second reason is to prevent pre-ignition. If the metal be permitted to heat up to a red heat, for instance, the fuel will ignite during the compression stroke, previous to the completion of same, and thus cause the engine to reverse.

There are two general types of cooling systems, the direct or air system, and the indirect or water system. The air system being termed a direct system, as there is no intermediate transfer of heat from the cylinder walls to the radiating surfaces, by means of a cooling liquid. Air cooling is generally effected by cooling ribs, which are cast integral with cylinder walls and some mechanical method of inducing air circulation.

The indirect cooling system involves the circulation of a liquid, such as water, the function of which is to absorb heat from the cylinder walls

and deliver same to a current of air which is passed over the surfaces of a radiator within which the water in its heated state is circulated, by means of a circulating pump, except in the cases involving the thermo syphon system of circulation. All water-cooled motors, so-called, are of the indirect cooled type.

The indirect system may be depicted as follows: Water is passed from the lower tank of the radiator to the pump mounted on the engine, which forces the water through a distributing manifold to the various cylinders of the engine. This water is usually entered at the bottom of the water jackets, and as it becomes heated it loses its specific gravity, rises, and flows out through the upper manifold to the top of the radiator, where it is distributed to the various tubes, through which it flows to the lower tank and is again circulated. These radiator tubes are separated by air spaces through which air passes, carrying off the heat units in the water.

The thermo syphon system is generally referred to as the natural circulating system. In this system the pump is eliminated and the circulating is induced by the heat of the motor. The water under the influence of heat sets up a circulation, and it can readily be understood that the heat replaces the pump as the moving force acting on the water.

In order that the cooling may be effective independent of the car speed, a fan must be used. To cool an engine as used in the modern type of motor car, under ideal conditions and most efficiently, would require a tremendously large radiator, if the car stood still, or the air was allowed to flow through it naturally. So to reduce the size to something that can be used, the relative efficiency is increased. This is done by inducing

an artificial flow of air. This is brought about in two ways. One is that the radiator does not stand still, but is moved with the car, indicating an air circulating through it. This, however, would not be effective with the car standing still and the engine running, so a second artificial circulating means is provided in the fan. This fan is

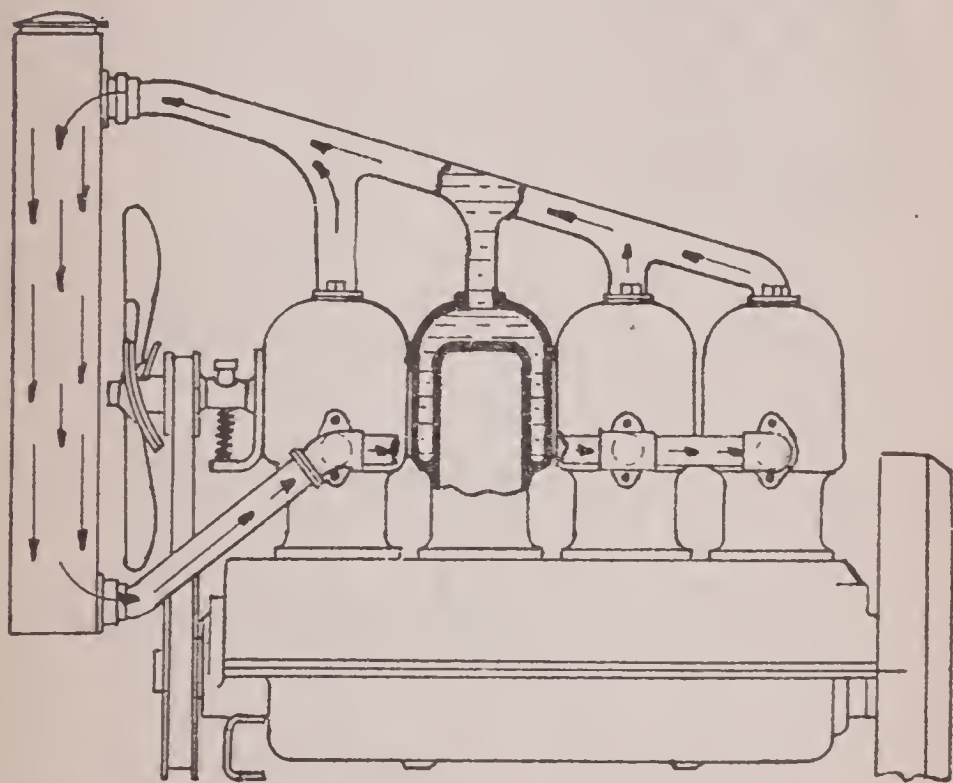


Fig. 92.—Thermo Syphon Cooling System.

driven from the engine and so rotates when the engine rotates. If the engine runs slowly and has little heat to dispose, the fan runs slowly. When the former turns over at the maximum rate of speed, the fan, too, is making the highest possible number of revolutions. The fan is most generally placed at the front end of the engine and directly in the rear of the radiator, drawing air through the radiator only, while lately there has been a tendency to combine the fan with the fly-wheel, drawing air through the radiator and thence across the whole engine, thus effecting secondary cooling.

Many different constructions of radiators are

in evidence upon the later models of motor cars, among which may be found the honeycomb, sometimes called the cellular, flat vertical tube and the built up round and flat tube types.

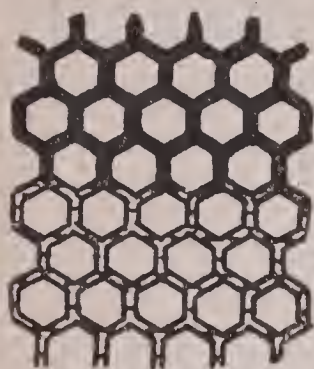


Fig. 93.—Honeycomb Type.

what is known as the cellular type, generally being termed honeycomb type. The construction is similar to that depicted above, excepting that square tubes are used instead of hexagonal. Flat vertical tubes, tubes with square corrugations and swaged or soldered edges to form water spaces are also used.

The flat vertical tube type consists of a series of rectangular shaped tubes fastened into a header, with fins attached to the tubes for heat radia-

The honeycomb type consists of a series of six-sided or hexagonal tubes fastened into a header in such a way as to allow of space between the tubes for the passage of water. This construction is quite expensive and was generally found on the high priced cars. This was later replaced by

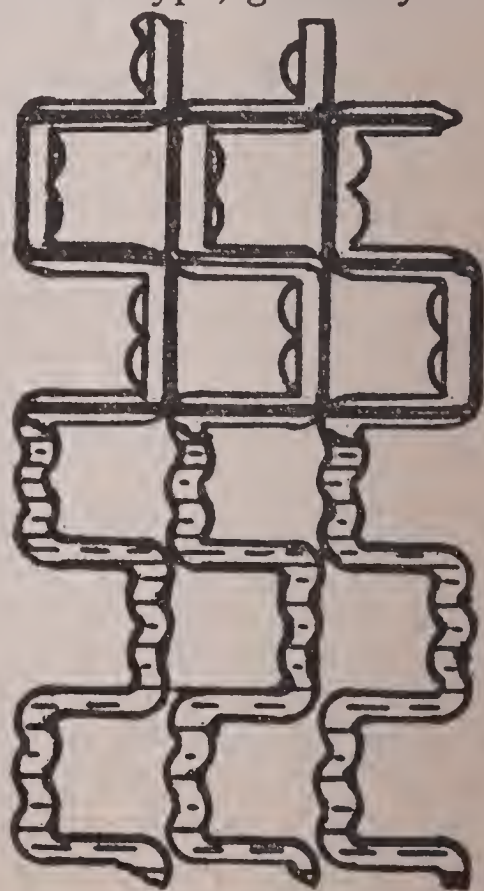


Fig. 94.—Mercedes Type.

tion and to strengthen vertical tubes. Various types of fin construction are used, and sometimes these are of the continuous type, the result of this

construction being a pleasing appearance similar to the cellular type. This latter type is more popular on the light popular-priced motor cars owing to its lower first cost.

In the majority of motor cars the radiator is located at the front end of the car, and so set that the air currents pass almost unobstructed through the passage ways.

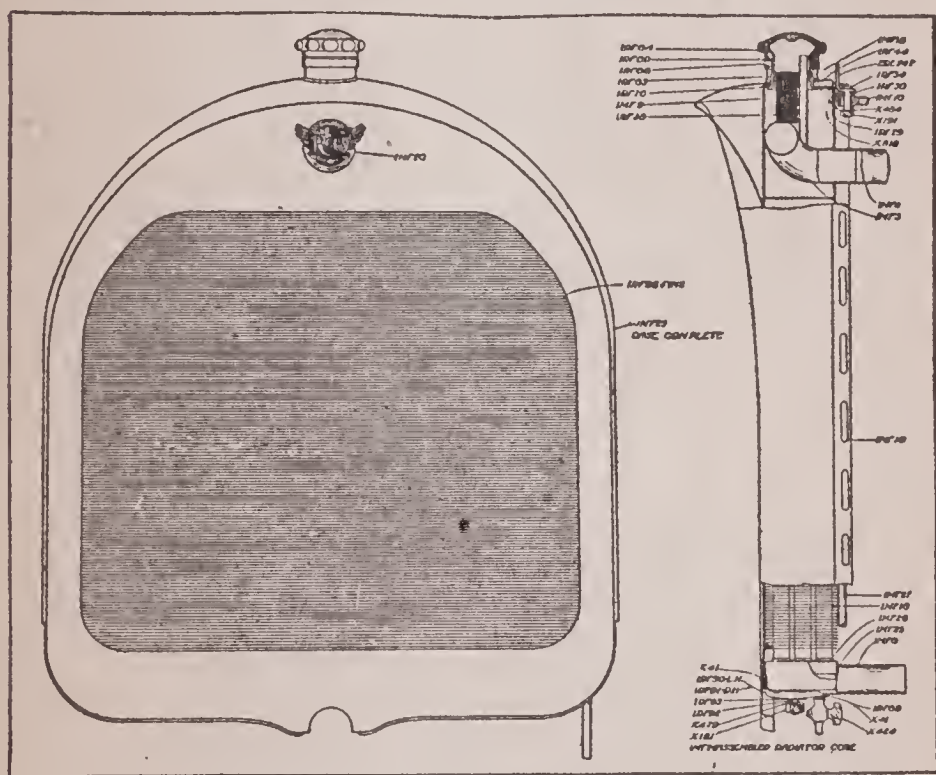


Fig. 95.—Reo Radiator.

This radiator is quite a frail unit and when the car is built in a unit with the outer shell it is quite difficult to obtain a stream-line effect for entire car. In order to overcome this, a shell is generally drawn to proper shape and the radiator arranged so that this can be bolted in the shell after it has been enameled. The Reo radiator shown herewith is of this construction.

There are two general types of pumps in use at the present writing, the gear type and the centrifugal type.

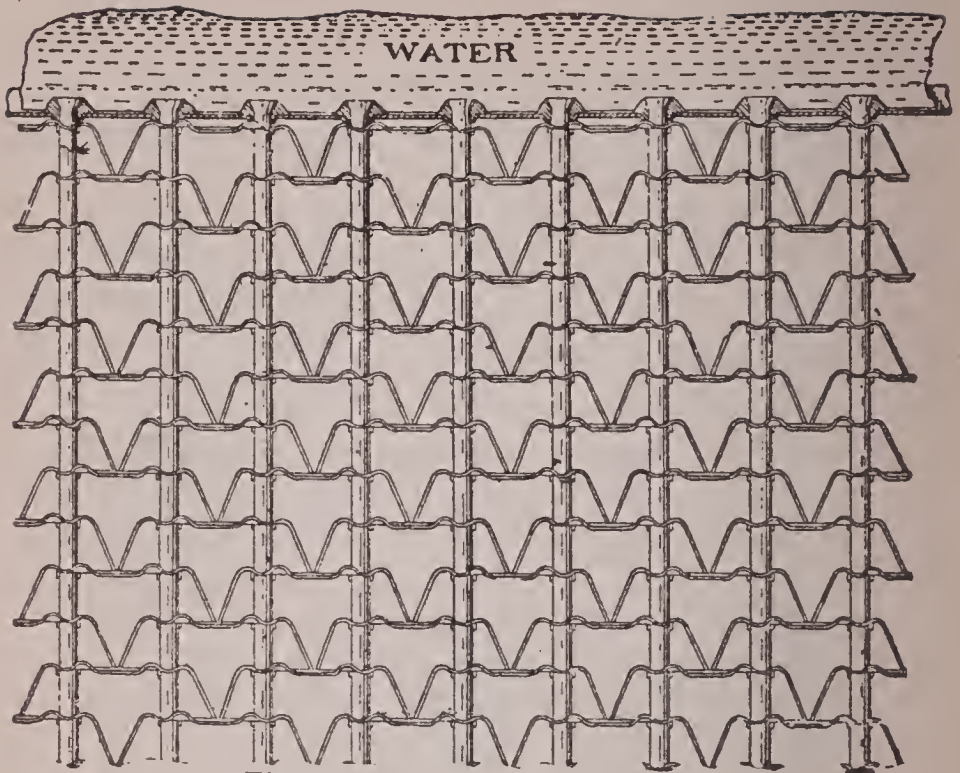


Fig. 96.—Vertical Tube Type.

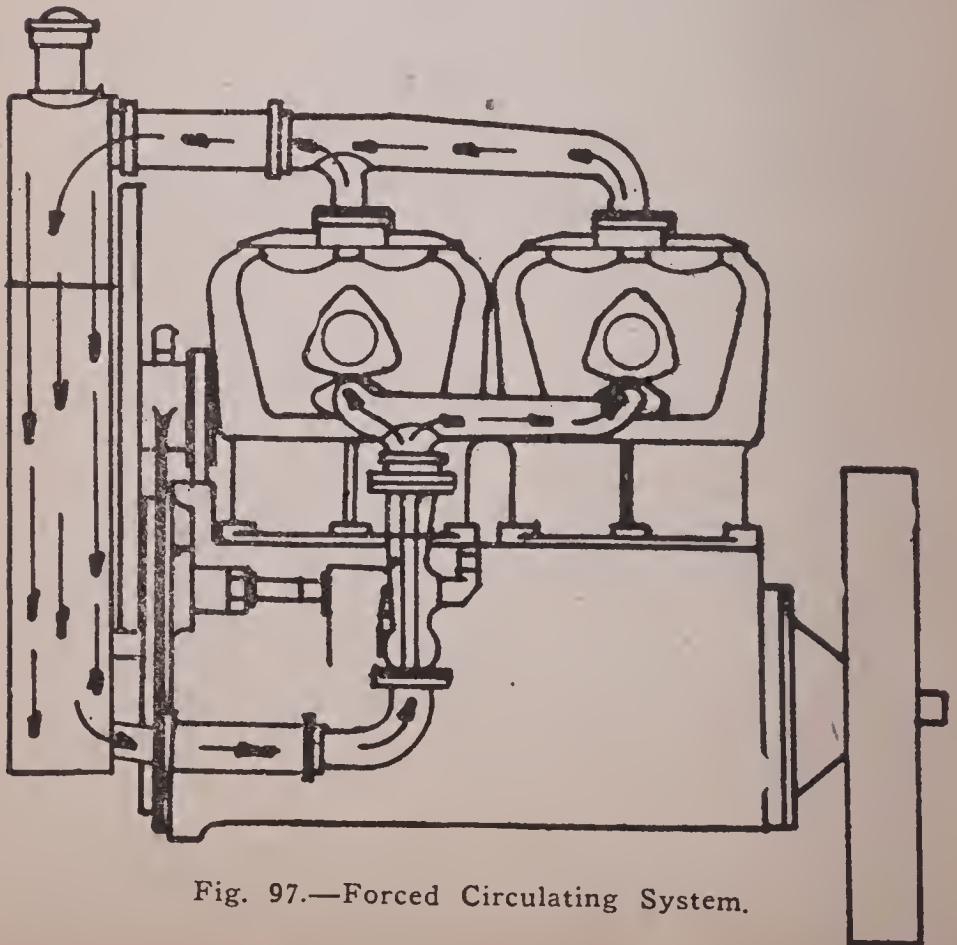
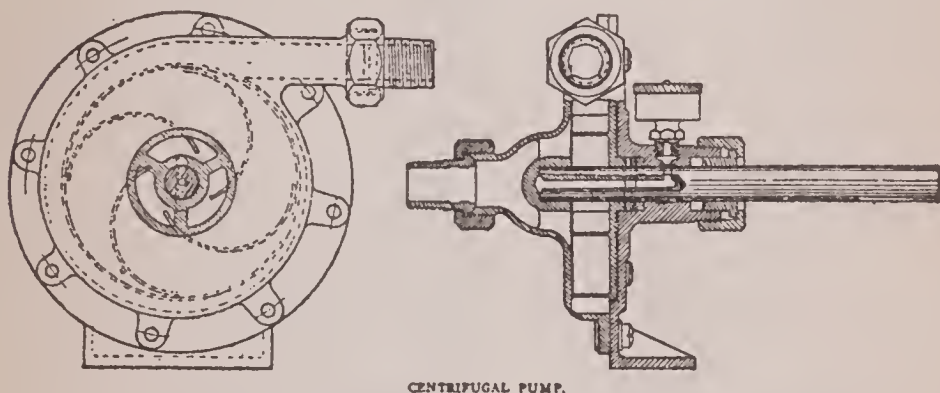


Fig. 97.—Forced Circulating System.

The essentials of the gear type of pump consist of a pair of gears, a pair of shafts for them to rotate on, and a case to house the gears, which acts as bearings for the shafts and to convey the water to and from the gears in the proper manner.

Water enters at the side of the meshing teeth and is carried around between the teeth and the housing to the outlet on the opposite side. The



CENTRIFUGAL PUMP.

Fig. 98.—Motor Cooling.

gear pump is simple in construction and maintenance.

As previously mentioned, eight and twelve-cylinder engines are generally provided with double water pumps arranged in a single unit. An example of this type is the Packard twin six pump, which consists of a double rotating member and double outlets which are arranged opposite each other. A single inlet is provided which communicates with the center of the rotating member and permits the water to be forced tending from the turning gear housing and are out through both outlets, each of which are connected with a cylinder bloc.

Both the gear and centrifugal types of pumps possess an advantage over all other types, in that they provide a continuous stream of water.

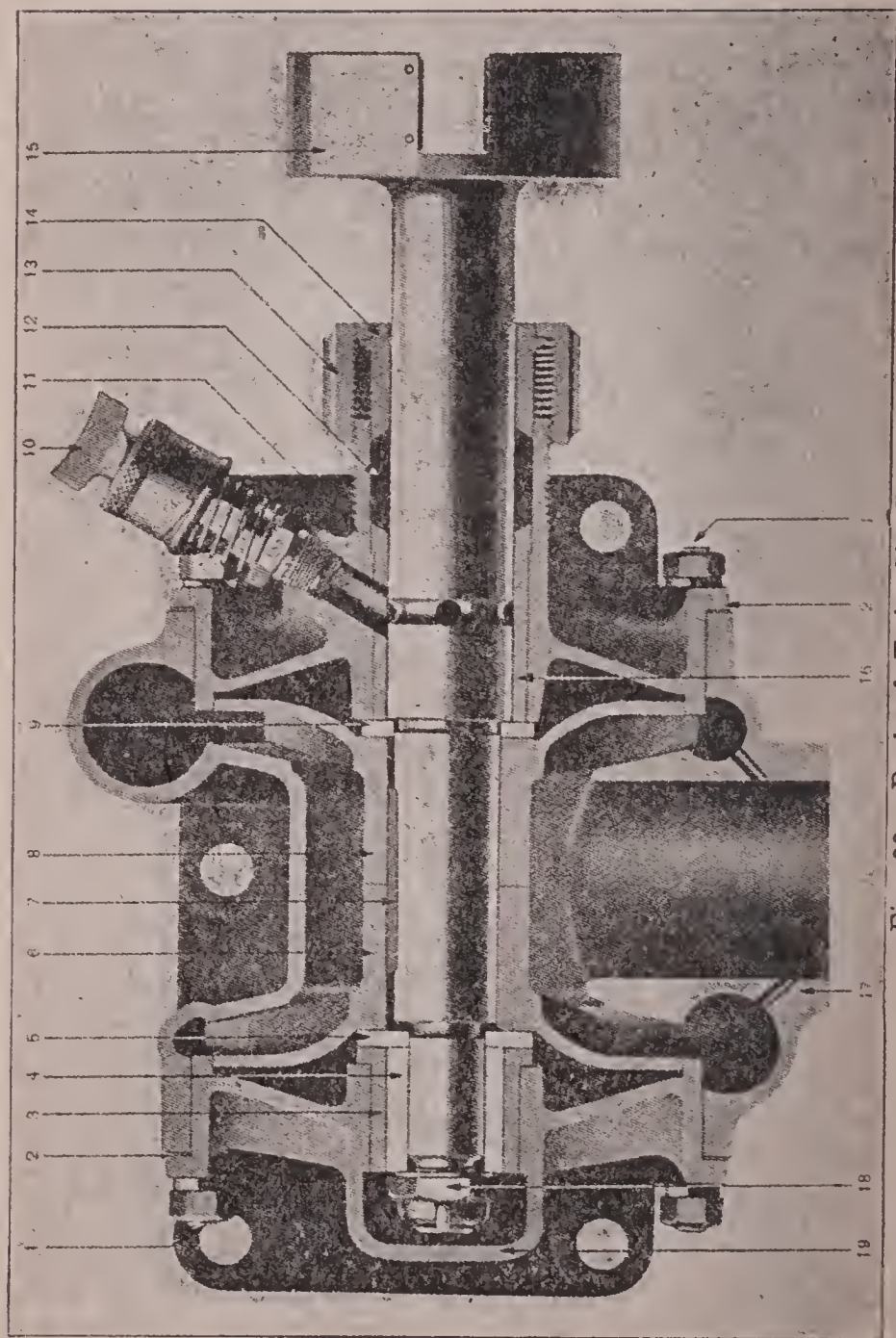


Fig. 99.—Packard Twin Six Pump.

Between these two types there is very little or no choice; they both do the work under substantially the same conditions, unless it is that the gear pump is more likely to become noisy.

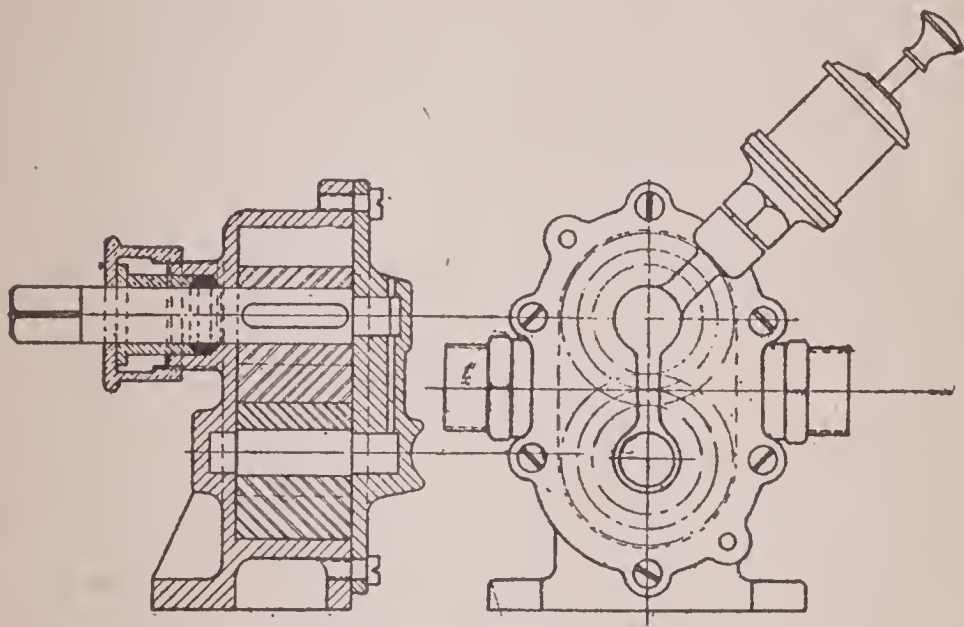


Fig. 100.—Gear Type Pump.

The centrifugal type of pump is perhaps the easiest of all to understand. It consists of a rotating member, which may either be formed integral with or keyed to the driving shaft, and a case and cover which house the rotating member. In operation it is rotated at high speed and the water entering at the center flows out on the arms and at the extremities is thrown off by centrifugal force. This throwing off action is restricted by the case, so that the effect is to throw the water into the outlet pipe.

The pumps are generally driven by shafts ex-provided with flexible or universal couplings. The coupling serving to keep the pump free from strains due to misalignment, and it is also in some cases so designed that when the pump freezes up the coupling will break before any damage is done to the pump.

Lately there has been a tendency to increase the size of the inlet and outlet pipes of the cooling system, providing as few bends as possible, in order to obtain a free passage for the water. Besides having these manifolds of adequate area, it is also necessary to arrange these manifolds so that one cylinder will not rob the other of its share of the cooling fluid.

Electric Wiring Plan and Coil Adjustment

THINGS TO KNOW THAT SAVE TROUBLE.

SHORT CIRCUITS. Any battery will be rapidly exhausted if it is allowed to stand on short circuit for any length of time. For this reason care should be taken not to place metal bars, tools, etc., on the battery where they might short circuit it.

When starting a car equipped with a dual system of ignition, the car should be cranked immediately after the switch is turned to the battery side and the magneto switched in at once. This is necessary, because in the majority of such systems the battery is short circuited all the time that the switch is on the battery side.

It is also well to thoroughly examine the switch on any system and to be sure it is free from any short circuits either when the switch is in the off position or on the magneto side. In many cases the battery has been found to be short circuited when the switch was on the magneto side or even in the off position.

WIRING. For primary wiring use about No. 14 gauge wire with approved insulation.

For secondary wiring special heavily insulated high tension wire should be used at all times.

Apparatus should be placed so that the length of the secondary leads shall be reduced to the minimum. These leads should not be placed too close to each other if they are more than 24 inches long.

High tension wires should never be placed so that they are liable to become soaked with oil or water.

Wires should never be left with loose ends exposed. They will cause trouble.

A loose contact will always cause trouble. The wires should be scraped until they are clean and bright after the insulation has been removed and all the joints should be made secure and taped.

Care should be taken that the ground wire makes good contact with the engine frame (not the body frame) in such a position that it is not liable to be broken.

All connections should be inspected regularly for loose or corroded joints.

SPARK PLUGS. Those that give satisfactory service on battery systems are often destroyed within a short time when used on magneto. Spark gaps about $3/64$ inch, or the thickness of a dime, will give good results with batteries.

In replacing spark plugs in hot cylinders, do not screw them in too tightly. They will be hard to remove.

GENERAL. Do not operate an ignition system with the secondary wires removed, unless a spark gap is provided through which the secondary may discharge.

Do not take it for granted that the ignition is at fault every time the engine stops or misses.

When using individual dry cells in steel battery box some form of lining should be provided. Ordinary floor matting makes an excellent lining.

When replacing a storage battery with dry cells the interior of the battery box should be thoroughly scrubbed to remove all acid, otherwise the zinc of the battery will be attacked and quickly destroyed. Cases have been known where a number of dry cells have been destroyed within a few days by the acid left in the battery box from a storage battery which was formerly used.

When using individual dry cells care should be

exercised in washing the car, so that the batteries and the interior of the battery box are not wet. This is apt to cause leakage of current, which will soon destroy the batteries.

CAUSES OF IGNITION TROUBLES.

In 99 cases out of 100 the motorist blames the batteries whenever anything goes wrong with his ignition. Experience has proved that the reverse of this is the actual condition.

As a guide to those who may be having ignition trouble we will list a few conditions and show some possible causes for the trouble, independent of the battery.

(a) Whenever the engine fires irregularly, the cause may be due to:

- (1) Broken down insulation on wires.
- (2) Carburetor not properly adjusted, causing poor mix.
- (3) Cracked spark plug.
- (4) A defective connection in some part of the circuit.
- (5) Gasoline feed partly choked.
- (6) Moisture on spark plugs or water in carburetor.
- (7) Poor contact in timer.
- (8) Spark coil not properly adjusted.
- (9) Terminals on coil may be loose or damaged.

(b) When the engine fires regularly, but is weak, the cause may be due to:

- (1) Compensating valve on carburetor not working.
- (2) Improper gas mixture.
- (3) Insufficient lubrication.

(4) Platinum contacts on coil may need cleaning.

(5) Poor compression caused by loose plugs or valves.

(6) Reduced lift on exhaust valve.

(7) Muffler outlets may be stopped with mud or charred oil.

(8) Vibrator on coil may need adjusting.

(9) Weak spring on inlet valve.

(c) When the engine refuses to start, the cause may be due to:

(1) Broken or jammed gears.

(2) Dry cylinders.

(3) Battery plug not in position.

(4) Fouled or cracked spark plug.

(5) Gasoline shut off.

(6) Improper gas mixture.

(7) Improper Ignition.

(8) Inlet valve stuck.

(9) Open battery switch.

(10) Poor compression.

(11) Water in cylinder caused by leak from water jacket.

(12) Water in gasoline.

(d) When there is a gradual slowing up of the engine, accompanied by misfiring, the cause may be due to:

(1) Carburetor may be choked with dirt at jet.

(2) Gasoline tank empty or air-bound.

(3) Gasoline valve partly closed.

(4) Fouled spark plugs, due to over or poor lubrication.

These are not all of the things that may cause your trouble, but serve to show you that there are many angles to the ignition question independent of the battery of whatever make or grade.

To sum up in a few words, here are a few things that may be the direct cause of poor ignition, and each has no connection with battery qualities. (1) Poor or loose connections in the wiring; (2) Poor battery connections; (3) Broken down insulation; (4) Fouled or leaky spark plugs; (5) Broken wires under the insulation somewhere in the circuit; (6) Defective switch; (7) Defective units in good types of coils; (8) Poor coils; (9) Impeded flow of gasoline; (10) Improper adjustment of carburetor; (11) Poor vibrator adjustment; (12) Leaky valves—and many other causes.

Valve Grinding

IF the average car owner only realized the importance of keeping the valves properly seated! Too much emphasis cannot be placed on the necessity of examining them carefully at regular intervals, even though the compression is apparently normal and uniform in each cylinder. The exhaust valves are especially susceptible to corrosion on account of the intense heat of the escaping gases. The seats soon become pitted, the carbon dust and vapor is caught and confined in every little crevice, and in an incredibly short space of time the valves, if neglected, will be covered with a deposit of carbon which will affect the running of the motor to a marked degree. The only remedy is to grind them.

Remember, you must by all means prevent even a minute particle of this grinding abrasive from

finding its way into the combustion chambers. Pack a good, generous quantity of waste or rags well soaked in gasoline around the valve seat and take due precaution to leave the inside of the cylinder casting perfectly clean.

Apply a moderate coating of the compound to the bevel face of the valve and return it to its seat. Next rotate valve forward and back until the entire bearing surfaces are polished bright and smooth the full width of the face. If the guide is worn or the stem bent great care must be exercised or the valve will not be "true"—i. e., the bevel face will not be flat, but a trifle convex. The valve should never be turned the whole way round. Oscillate it back and forth a quarter turn at most under light pressure, lifting it up frequently and turning it half way round before seating it again. This method distributes the friction evenly and eliminates the possibility of the emery scoring the bearings. If no valve grinding tool is available, the use of a carpenter's bit stock is advised, as a much smoother movement is thus obtained than by using a screwdriver.

After working up a good clean seat, entirely free from spots or pits, wash the valve, valve seat and guide thoroughly in gasoline. If the stem is rough or gummy, smooth it up with emery cloth, but clean it afterwards and oil it before replacing.

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